Freshwater Fish Inventory of the Alagnak Watershed, Alagnak Wild River, Southwest Alaska Inventory and Monitoring Network

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ABSTRACT

A freshwater fish inventory was conducted from March through August, 2002 in the Alagnak Watershed. The objectives of the inventory were (1) to document species that were *expected yet undocumented* and (2) to provide initial descriptions of the distributions, abundance, and biologic characteristics of these species. Minnow traps, minnow seines, beach seines, snorkel gear, hand nets, fyke nets, tow nets, gill nets, hook-and-line, and a gastric lavage were used to sample fish. River, lake, pond, and stream habitats were sampled. Nine of 14 expected but undocumented species were captured or observed: Alaska blackfish (*Dallia pectoralis*), Arctic lamprey (*Lampetra japonica*), burbot (*Lota lota*), coastrange sculpin (*Cottus aleuticus*), ninespine stickleback (*Pungitius pungitius*), northern pike (*Esox lucius*), round whitefish (*Prosopium cylindraceum*), slimy sculpin (*Cottus cognatus*), and threespine stickleback (*Gasterosteus aculeatus*). The fish community of the Alagnak Watershed appears to have fewer species (lower species richness) than the adjacent Naknek and Kvichak systems.

EXECUTIVE SUMMARY

The National Park Service's (NPS) Inventory and Monitoring Program has begun a nationwide inventory of natural resources within park units. As part of this effort, freshwater fish inventories are being conducted in the Southwest Alaska Network (SWAN), including watersheds in Katmai National Park and Preserve (KATM), Alagnak Wild River (ALAG), Aniakchak National Monument and Preserve (ANIA), Kenai Fjords National Park (KEFJ), and Lake Clark National Park and Preserve (LACL). The 2002 field effort focused on the Alagnak River Watershed within ALAG and KATM.

The primary objective of the inventory was to document, through capture or observation, fishes that were *expected yet undocumented* in the Alagnak Watershed. A secondary objective was to provide initial descriptions of the distributions, abundance, and biologic characteristics of these species. The list of expected but undocumented species list was based on fish communities of adjacent watersheds and included 14 species (listed alphabetically by common name followed by scientific name): Alaska blackfish (*Dallia pectoralis*), Arctic lamprey (*Lampetra japonica*), burbot (*Lota lota*), coastrange sculpin (*Cottus aleuticus*), humpback whitefish (*Coregonus clupeaformis*), least cisco (*Coregonus sardinella*), longnose sucker (*Catostomus catostomus*), ninespine stickleback (*Pungitius pungitius*), northern pike (*Esox lucius*), pond smelt (*Hypomesus olidus*), pygmy whitefish (*Prosopium coulteri*), round whitefish

(*Prosopium cylindraceum*), slimy sculpin (*Cottus cognatus*), and threespine stickleback (*Gasterosteus aculeatus*) (AKNHP 2000).

The inventory focused on Nonvianuk Lake, Kukaklek Lake, and the Alagnak River. Nonvianuk Lake and Kukaklek Lake (12,000 ha and 14,000 ha, respectively) are the largest lakes in the watershed. Nonvianuk Lake drains into the Alagnak River from an elevation of 192 m via the Nonvianuk River. Kukaklek Lake is the origin of the Alagnak River at an elevation of 246 m. The Alagnak river flows 120 km before draining into the Kvichak River and then Bristol Bay. The Alagnak watershed overlaps Katmai National Park and Preserve and the Alagnak Wild River.

The inventory was conducted during the spring and summer of 2002, using a a variety of sampling gear. These included minnow traps, minnow seines, beach seines, snorkeling gear, hand nets, fyke nets, tow nets, gill nets, hook-and-line, and a gastric lavage.

Nine of the 14 *undocumented but expected* species were captured or observed during the inventory. These included (alphabetically) Alaska blackfish, Arctic lamprey, burbot, coastrange sculpin, ninespine stickleback, northern pike, round whitefish, slimy sculpin, and threespine stickleback.

The distributions and relative abundance of the nine documented species were not uniform. Ninespine stickleback, round whitefish and slimy sculpin were found in all of the sampling areas. Alaska blackfish, Arctic lamprey and northern pike were observed or captured in the Alagnak River but not in lake habitats. Ninespine sticklebacks were relatively abundant in the Alagnak River and Nonvianuk Lake but rare in Kukaklek Lake. Threespine sticklebacks were not found in the Alagnak River but were relatively abundant in both Nonvianuk and Kukalek Lakes. Coastrange sculpins were found frequently in Nonvianuk Lake but were not detected in Kukaklek Lake and were rare in the Alagnak River. Burbot were only found in Kukaklek Lake

The nine species documented during the inventory are consistent with known distribution patterns in southwest Alaska. No range extensions or unexpected species were identified within the Alagnak watershed. Five expected species were not detected: humpback whitefish, least cisco, longnose sucker, pond smelt, and pygmy whitefish. There are two explanations for the missing species: (1) incomplete documentation (i.e., not all species present in the Alagnak were detected during the inventory), or (2) the missing species are simply not present in the areas sampled.

Although valuable information was obtained, the Alagnak freshwater fish inventory represents an incomplete picture of species composition in this system. More work is needed to determine whether undocumented species are present, as well as the abundance, distributions and biological characteristics of the documented species.

Key Words

Alagnak Wild River, Alaska blackfish, Arctic lamprey, burbot, coastrange sculpin, humpback whitefish, inventory, Katmai National Park and Preserve, least cisco, longnose sucker, ninespine stickleback, northern pike, pond smelt, pygmy whitefish, round whitefish, slimy sculpin, and threespine stickleback.

INTRODUCTION

The National Park Service's (NPS) Inventory and Monitoring Program has begun a nationwide inventory of natural resources within park units. As part of this effort, freshwater fish inventories are being conducted in the Southwest Alaska Network (SWAN). SWAN comprises Katmai National Park and Preserve (KATM), Alagnak Wild River (ALAG), Aniakchak National Monument and Preserve (ANIA), Kenai Fjords National Park (KEFJ), and Lake Clark National Park and Preserve (LACL). Portions of KATM and LACL have been inventoried (Heard et al. 1969; Russell 1980) but the majority of the network has not. One of the major watersheds that has received the least amount of attention is the Alagnak. Located in both the ALAG and KATM boundaries, the Alagnak Watershed was the focus of the 2002 freshwater fish inventory and represented the first of several locations to be inventoried within SWAN as part of the current inventory and monitoring program.

The Alagnak River Watershed provides freshwater habitat for resident and anadromous fish species. However, little is known about species richness or community composition within the lakes and rivers that make up the Alagnak. The data that are available concern species targeted by sport and commercial fishers; salmon, trout, and grayling, and represent a narrow view of the system.

The majority of resident freshwater fishes present in the Alagnak Watershed have not been formally documented. The undocumented species are of little economic importance but are integral pieces of the ecosystem and may have a significant value to subsistence fishers. These include a broad range of fishes with highly diverse life histories and variable habitat requirements: sculpin, lamprey, whitefish, smelt, sticklebacks, blackfish, burbot, and pike.

The lack of information surrounding undocumented species presents a number of problems for resource managers. First, it is extremely difficult to understand ecological interactions within an ecosystem without knowing what species are present in that ecosystem. Species composition directly affects interspecific competition levels, predator-prey relationships, habitat partitioning and, subsequently, growth rates, population dynamics, and natural selection. Second, detecting the effects of environmental change, whether human induced or natural is problematic without species presence data. Subtle changes in the physical or biological characteristics of freshwater habitat may result in local extinction, range extension, or variation in life-history tactics. Without baseline data to serve as a reference point, documenting or responding to these events is difficult. Finally, harvest management decisions are compromised by a lack of species presence/absence data. Setting harvest limits or determining when overharvest occurs are arbitrary processes for species that are undocumented. Ultimately, both the fish and fishers are vulnerable to mismanagement under these circumstances.

The primary objective of the inventory was to document, through capture or observation, fishes that were *expected yet undocumented* in the Alagnak Watershed. A second objective was to provide initial descriptions of the distributions, abundance, and biologic characteristics of these species. The list of expected but undocumented fishes was based on fish communities of adjacent watersheds and included 14: Alaska blackfish *(Dallia pectoralis)*, Arctic lamprey *(Lampetra japonica)*, burbot *(Lota lota)*, coastrange sculpin *(Cottus aleuticus)*, humpback whitefish *(Coregonus clupeaformis)*, least cisco *(Coregonus sardinella)*, longnose sucker (*Catostomus catostomus)*, ninespine stickleback *(Pungitius pungitius)*, northern pike *(Esox lucius)*, pond smelt *(Hypomesus olidus)*, pygmy whitefish *(Prosopium coulteri)*, round whitefish *(Prosopium cylindraceum)*, slimy sculpin *(Cottus cognatus)*, and threespine stickleback *(Gasterosteus aculeatus)* (AKNHP 2000).

METHODS AND MATERIALS

Inventory Location

The inventory focused on three major regions within the Alagnak Watershed: Nonvianuk Lake, Kukaklek Lake, and the Alagnak River. Nonvianuk Lake and Kukaklek Lake are the largest lakes in the watershed at 12,000 ha and 14,000 ha respectively. Nonvianuk Lake drains into the Alagnak River from an elevation of 192 m via the Nonvianuk River. Kukaklek Lake is the origin of the Alagnak River at an elevation of 246 m. The Alagnak river flows 120 km before draining into the

Kvichak River and then Bristol Bay. The Alagnak watershed overlaps Katmai National Park and Preserve and the Alagnak Wild River (Figure 1).

Fish Sampling

The inventory was conducted during the spring and summer of 2002. The Alagnak River was inventoried from 5-13 June and 31 July-1 August 2002. Nonvianuk Lake was inventoried on 20-21 March, 21-29 June, 20-23 July, and 6-10 August 2002. Kukaklek Lake was inventoried on 25-26 April, and 7-14 July 2002.

Specific sampling sites within each region were chosen by examining the habitat requirements of *expected but undocumented* species. These habitat requirements were related to physical habitat features that were observable in the field or by using topographic maps and aerial photos. Targeted habitat for Alaska blackfish and Northern Pike included vegetated backwater areas, ponds and side channels. Adult Arctic lamprey were expected to be found in river habitats drifting downstream and ammocoetes in muddy substrates. Burbot were expected to be found in benthic lake habitat and large pools in river habitat. Coastrange sculpin, longnose sucker, and slimy sculpin were expected to be in close association with cobble or gravel habitat in lakes and flowing waters. Humpback whitefish were expected to be found in littoral regions of lakes and in the mainstem of the Alagnak River. Least cisco and pond smelt were targeted in limnetic and littoral portions of the lakes. Ninespine stickleback were expected to be found in side channels of the Alagnak River and in littoral regions of the lakes. Pygmy whitefish and round whitefish were expected to be in littoral and benthic lake habitats. Threespine stickleback were predicted to be ubiquitous within the lakes (e.g., Rogers 1967; Heard et al. 1969; McPhail and Lindsey 1970; Russell 1980).

Efforts were made before sampling began to identify these specific habitats for sampling, but the majority of sampling sites were chosen in the field. This judgement-based approach was an attempt to maximize the probability of encounter with undocumented species given a short field season and a large watershed.

Upon arrival at each sampling site, the latitude and longitude, time, water depth, and a brief habitat assessment were recorded. Latitude and longitude were determined with a Garmin® GPS 76 (WGS 84 datum). The time was recorded at the start and conclusion of the sampling event. A portable Hummingbird® Piranha II depth sounder was used to determine water depth. Habitat appearance and type was qualitatively assessed for the environment in the immediate vicinity of the sampling gear. This assessment involved a description of water movement, fluvial characteristics, ice conditions, and general observations.

A number of different sampling techniques and gear types were employed to document species presence in specific habitat types (habitats follow gear type parenthetically): minnow traps (benthic, littoral lake, main channel river, side-channel river, ponds), minnow seines (littoral lake, side channel river, ponds), beach seines (littoral lake), snorkeling gear (all shallow habitats), hand nets (all habitats), fyke nets (main channel river, side channel river), tow nets (epilimnetic lake), gill nets (littoral lake, limnetic lake), hook-and-line (all habitats), and gastric lavage (all habitats). Murphy and Willis (1996) provide general descriptions, theoretical discussions, and caveats of these sampling techniques, but some of the variations we employed were specific to the inventory.

Minnow traps were baited with either salmon eggs or salmon flesh and were set by boat or from shore. Traps were fished for two to 24 h at depths ranging from 1 m to 20 m. In waters 2 m and deeper, traps were marked with a buoy and anchored with a 3-5 kg sand bag.

The minnow seine was set from a shore-based location and fished in shallow areas less than 1 m deep. Its dimensions were 15 m long by 1 m deep with a homogenous mesh size of 12.7 mm (all mesh sizes represent diagonal or stretched measurements as opposed to square or bar measurements).

The beach seine was deployed, using a 4 m Zodiac® raft powered by a 25 hp outboard, in waters less than 4 m deep and along shorelines where large snags were not apparent (e.g., beaches with large boulders or submerged trees were avoided). The net was 30.5 m long and about 4 m deep and comprised 10 variable mesh panels. The variable mesh panels were symmetric about the midline of the net with the smallest sizes near the center and largest at the ends. In total there were five different mesh sizes: 3.2 mm, 4.8 mm, 6.4 mm, 12.7 mm, 22.2 mm.

Snorkeling was performed during the day, along river and lake shorelines where water depths ranged from 0.5 m to 5 m. Snorkeling surveys usually lasted for 10 to 30 min and were only performed when water clarity was sufficient to identify fishes. A hand net was used to capture fishes observed while snorkeling. Because of the small size of our sampling operation and general safety concerns, only one person snorkeled at a time.

The fyke net had an entrance 1.2 m by 1.2 m tapering down to a round cod-end about 0.5 m in diameter. Two mesh panels (1.2 m deep by 3 m long), suspended from either side of the net, directed fish into the entrance. Both the net and panels were constructed from 6mm mesh. The net was fished in flowing waters less than 1 m deep to capture fishes moving downstream. The net was cleaned and its contents checked on an hourly basis. The size and design was based on fyke nets used by the Alaska Department of Fish and Game for salmon smolt studies (e.g., Crawford and Cross 1995).

The tow net was fished in epilimnetic regions (surface waters) of Nonvianuk and Kukaklek lakes at a maximum depth of 1.8 m. It was towed between two boats (either 4 m Zodiac rafts powered by 25 hp prop outboards or 5 m aluminum skiffs powered by 50hp jet outboards), for 15 min intervals, at or immediately before sunset. The net was about 5.5 m long with a square mouth (1.8 m x 1.8 m). From the mouth the net tapered down to a 0.8 m diameter cod-end. As the net tapered so did the mesh size: 4.4 cm at the mouth, 2.5 cm in the center, and 0.5 cm at the cod-end.

Gill nets were fished across a range of depths and at surface and subsurface locations. They were fished from one to 24 h and were checked about once an hour. Two types of gill nets were used: variable mesh (experimental) and uniform mesh. The variable mesh net had seven panels, each 2.4 m deep by 6.1 m long with mesh sizes of 2.5 cm, 3.8 cm, 5.0 cm, 6.4 cm, 7.6 cm, 10.2 cm, and 15.2 cm. The uniform mesh net was 2.4 m deep by 30.5 m long with a mesh size of 2.5 cm.

Hook-and-line sampling was performed with set lines and conventional fishing rods and reels. Gear was deployed from boats, shore, and through surface ice. Both artificial lures and bait (salmon flesh) were used.

Gastric lavage was employed to examine the stomach contents of large predatory fish and, indirectly, determine species presence. The lavage was performed using a water-filled 100 cc syringe with a blunted tip. The syringe tip was inserted into the esophagus of a fish and water was pumped into the stomach, which in turn caused involuntary gastric evacuation.

The use of specific sampling techniques varied by season and sampling environment. During the spring (March and April), when the lakes were covered with ice, minnow traps, and hook-and-line gear were used exclusively. An ice auger was used to drill holes in the ice for gear deployment. In summer months (June, July, and August), after surface ice had melted, seines, gill nets, tow nets, fyke nets, snorkel gear, hand nets, minnow traps, and hook-and-line were used. Fyke nets were used only in rivers, while tow nets and beach seines were used only in lakes.

Processing fish samples involved anaesthetizing, identifying, counting, measuring and then releasing or retaining individual fish. A clove oil mixture (10 parts ethanol to one part clove oil) was used to anesthetize fish prior to identification and measuring. The clove oil mixture was added directly to the water in which captured fish were held. The amount of clove oil added to each sample varied depending on the species and size of the fish. In general, small amounts of the mixture (about 1 ml mixture per liter of water) were sequentially added, at intervals of about two minutes, until the fish became lethargic and could be handled easily. Anesthetized fish were identified to species level using dichotomous keys (McPhail and Lindsey 1970; Mecklenburg et al. 2001). Fish samples were counted and a subsample measured for length [fork length (FL) or total length (TL)]. We attempted to measure at least 200 randomly selected individuals of each species captured at each major waterbody (Alagnak River, Kukaklek Lake, and Nonvianuk Lake). Following measurment, most fish were released, however, some fish or fish parts were retained as voucher samples. There were two types of voucher samples: tissue and whole-fish. Tissue sampling was non-lethal and consisted of taking a small fin-clip, usually from the caudal fin, and preserving it in 95% ethanol. We attempted to collect tissue samples from at least 50 individuals of each species from each major waterbody. Whole fish samples were collected when the identity of the fish could not be determined in the field and also for morphological comparisons. Whole fish that were retained as voucher samples were killed by exposure to a lethal dose of clove oil and then preserved in formalin or ethanol. Voucher specimens (Appendix A) will be sent to the University of Alaska Museum Fish Collection for curation and verification of species identity.

Analysis

Data were analyzed using geographic information system (GIS) and statistical approaches. GIS was used to illustrate species presence within each of the major regions of the Alagnak Watershed. Fish species presence, latitude and longitude, date, and gear type were first entered into a D-base table and imported into Arc View as species-specific themes. Species themes were displayed in Arc View as overlays on a topographic map. Specifically, the overlays indicated where different species were observed, the gear used to capture or observe them, and the date of the observation. The presentation of GIS products is limited to geographic locations of capture and observation.

Statistical analyses were descriptive in nature and limited to morphological and catch data. The mean FL or TL and standard deviation (SD) for each species was calculated among geographic regions. Also, the catch per unit of effort (CPUE) for each gear type, species, and location was calculated.

RESULTS

Nine of 14 *undocumented but expected* species were captured or observed during the inventory. These included Alaska blackfish, Arctic lamprey, burbot, coastrange sculpin, ninespine stickleback, northern pike, round whitefish, slimy sculpin, and threespine stickleback.

The distributions and relative abundance (based on CPUEs) of the nine documented species were not uniform among the three major sampling areas (Alagnak River, Kukaklek Lake, Nonvianuk Lake). Only ninespine stickleback, round whitefish and slimy sculpin were found in all of the sampling areas. Alaska blackfish, Arctic lamprey and northern pike were all observed or captured in the Alagnak River but not in lake habitats. Ninespine sticklebacks were relatively abundant in the Alagnak River and Nonvianuk Lake but rare in Kukaklek Lake. Threespine sticklebacks were not found in the Alagnak River but were relatively abundant in both Nonvianuk and Kukalek Lakes. Coastrange sculpins were found frequently in Nonvianuk Lake but were not detected in Kukaklek Lake and were rare in the Alagnak River. Burbot were only found in Kukaklek Lake (Table 1).

For some of these species, enough individuals were collected to describe size ranges and age classes representative of their populations (Table 1). The best examples were ninespine stickleback, round whitefish, and threespine stickleback as they were the most commonly captured and measured.

Over the course of the inventory, the sampling effort varied at each location. On the Alagnak River minnow seines, fyke nets, and minnow traps were used most often (Table 2). At Kukaklek and Nonvianuk Lake beach seines and minnow traps were used most often (Table 2).

The results below describe the relative abundance, length frequencies, and CPUEs for the documented species among the major sampling regions of the watershed; Alagnak River, Kukaklek Lake, and Nonvianuk Lake.

Alagnak River

Seven of the expected but undocumented species were captured or observed in the Alagnak River: Alaska blackfish, Arctic lamprey, coastrange sculpin, ninespine stickleback, northern pike, round whitefish and slimy sculpin (Table 1).

Alaska blackfish— A total of nine blackfish were captured in the Alagnak River (Figure 2). Blackfish ranged in TL from 41 to 117 mm (mean TL=78.9 mm, SD=29.7, n=9), but the length frequency distribution did not indicate clear age groups (Figure 3). Some individuals over 100 mm appeared to be mature males based on prominent white or red edges on their anal, caudal, and dorsal fins. Blackfish were captured in minnow seines and baited minnow traps, however, the corresponding CPUEs for both of these techniques were very low (Table 3).

Blackfish were found to inhabit areas where aquatic macrophytes or inundated terrestrial vegetation were present and the water velocity was near zero. These types of habitats were found in side-channel areas, beaver ponds, and where spring-fed channels originated.

Arctic lamprey—Ten Arctic lampreys were captured in the Alagnak River (Figure 4). Lamprey ranged from 138 to 265 mm (mean TL=231.2 mm, SD=48.9, n=10)(Figure 3). All individuals were adults.

Lampreys were captured in flowing waters (riffles or glides) using a fyke net or a hand net. The fyke net captured lampreys drifting downstream (9 individuals) while the hand net was used once when a lamprey was observed from shore. All captures were made within 3 meters of shore and in water less than 1 m deep. The most effective capture technique, the fyke net, yielded less than one lamprey per hour (Table 3).

***Coastrange sculpin*—**A single 41 mm (TL) coastrange sculpin was captured in the Alagnak River (Figure 5). The sculpin was captured using a fyke net in an area with flowing water, gravel substrate, and a water depth of less than 1 m.

***Ninespine stickleback*—**Ninespine sticklebacks were the most frequently captured species (Table 1) during the Alagnak River portion of the inventory (Figure 6). Total length ranged from 38 to 68 mm (mean TL=52.2 mm, SD=7.0, n=179). The unimodal distribution of the length frequency plot indicated the predominance of a single age class within our samples (Figure 3).

Ninespine sticklebacks were captured using a minnow seine, fyke net, and minnow traps. Minnow traps were responsible for the bulk of the captures (507 individuals) (Table 3).

Ninespine sticklebacks were primarily found in low velocity environments. These included side channels, beaver ponds, and off channel areas with ephemeral connections to the Alagnak mainstem. They were also found at the interfaces between the mainstem river and low flow environments, particularly at the edge of the mainstem channel (nearshore areas).

Northern Pike— Four northern pike were captured in the Alagnak River during August 2002 (Figure 7). They ranged in FL from 320 mm to 660 mm (mean FL=486.7 mm, SD=170.1, n=3). A single pike less than 150 mm was also observed but not captured. The range of sizes observed indicated the presence of multiple age classes.

All pike were captured or observed in shallow, side-channel areas where aquatic macrophytes were present and water velocity was zero. In these areas, pike were observed just below the surface of the water. No pike were observed or captured at Kukaklek Lake or Nonvianuk Lake.

Round Whitefish—A group of approximately 5 round whitefish were observed but not captured in the Alagnak River during August 2002 (Figure 8). They were observed swimming along the gravel riverbed among migrating pink, chum, and chinook spawners.

Slimy Sculpin— Thirty-eight slimy sculpin were captured in the Alagnak River (Figure 9). Slimy sculpin ranged from 49 to 79 mm (mean TL=60.5 mm, SD=7.7, n=32). Over this range of lengths, it is likely that most of the individuals captured were adults of several age classes (Figure 3).

Slimy sculpin were captured in a minnow seine, fyke net, minnow traps, and with a hand net during snorkeling activities. Snorkeling also provided some general observational data: slimy sculpin were usually approachable, they were associated with benthic habitats, they were generally found near cobble or gravel dominated substrates, and they were found in mainstem and side channel areas (both high and low velocity habitats).

Kukaklek Lake

Five of the expected but undocumented species were captured or observed in Kukaklek Lake: burbot, ninespine stickleback, round whitefish, slimy sculpin, and threespine stickleback (Table 1).

***Burbot*—**Three burbot were collected in the nearshore waters of Kukaklek Lake (Figure 10). Burbot ranged in TL from 560 to 770 mm (mean TL=698.3 mm, SD=119.8, n=3), and were assumed to be adults based on these lengths (Russell 1980). Two of the three burbot were caught on set lines during the spring, when Kukaklek Lake was still covered with about 1 m of ice. The substrate beneath the ice was visible and appeared to be cobble and gravel. The third burbot, which was captured in July, was found floating at the surface of the lake approximately 30 m from shore. Although no external injuries were found, the burbot appeared to be stressed and near death.

Ninespine stickleback—Thirteen ninespine sticklebacks were captured in Kukaklek Lake (Figure 6). Ninespine stickleback ranged in TL from 32 to 54 mm (mean TL=41.3 mm, SD=10.2, n=4). They were captured during the summer portion of the inventory in beach seines and minnow traps. The CPUEs (Table 4) indicate low catch rates for both techniques. Compared to the Alagnak River, catches of this species in Kukaklek Lake were very low; about 100 times fewer fish/trap-hour using minnow traps and twelve times fewer fish/set using a beach seine (vs. the smaller minnow seine used on the Alagnak River).

Ninespine sticklebacks were captured in the shallow littoral regions of Kukaklek Lake using a beach seine and deeper benthic areas using minnow traps. A large proportion of these fish appeared to be males in spawning colors with dark brown or black abdomens and white ventral fins/spines.

Round Whitefish—Eighty round whitefish were captured in Kukaklek Lake (Figure 8). They ranged in FL from 43 to 400 mm (mean FL=145.2 mm, SD=66.1, n=72). The length frequency plot for this species was multi-modal indicating the presence of several juvenile and adult age classes (Figure 11).

Round whitefish were caught exclusively in the littoral zone of Kukaklek Lake, at depths of 4 m or less, using a beach seine and an experimental gill net. The beach seine yielded about 2.55 fish/set while the gill net caught about 0.13 fish/hour (Table 4). The smaller mesh panels of the experimental gill net (2.5 cm and 3.8 cm mesh) and the entire non-experimental gill net (2.5 cm mesh) were ineffective for catching this species.

Slimy Sculpin—Fifty one slimy sculpin were captured in Kukaklek Lake (Figure 9). They ranged in TL from 29 mm to 74 mm (mean TL=54.9 mm, SD=9.4, n=39). Across this range of sizes it is likely that both adults and juveniles were represented. The length frequency plot for this species appears unimodal and suggests the predominance of one age class in our samples (Figure 11).

Slimy sculpin were captured in the beach seine and in minnow traps. The beach seine produced 1.35 fish/set and the minnow traps 0.01 fish/trap-hour. Slimy sculpin were caught in littoral areas using a beach seine and shallow minnow traps (2 m and 5 m), and they were captured in deeper benthic habitats using 10 m and 20 m minnow traps. A single slimy sculpin was captured through the ice with a minnow trap during spring sampling.

Threespine Stickleback— Five thousand one hundred and fifty three threespine sticklebacks were captured during the Kukaklek Lake portion of the inventory

(Figure 12). They ranged in TL from 20 to 77 mm (mean TL=48.8 mm, SD=16.3, n=454)

At least three different modes, each indicating an individual age class, were evident in the length frequency plot of our samples (Figure 11). Among these age classes juvenile and adult sticklebacks were represented. Some of adult males exhibited blue and red spawning coloration.

Threespine sticklebacks were captured in a beach seine and minnow traps in littoral and benthic locations. The CPUEs for both techniques were greater than an order of magnitude higher than those observed for other species captured in Kukaklek Lake (Table 4). The CPUE calculations for the beach seine were weighted heavily by several large catches. The largest of these catches, greater than 1,000 individuals, comprised exclusively juvenile sticklebacks less than 35 mm long.

Nonvianuk Lake

During the Nonvianuk portion of the inventory, five of the expected but undocumented species were observed or captured: coastrange sculpin, ninespine stickleback, round whitefish, slimy sculpin and threespine stickleback (Table 1).

***Coastrange Sculpin*—**A total of 46 coastrange sculpin were captured at Nonvianuk Lake (Figure 5) ranging in TL from 28 to 78 mm (mean TL=46.4 mm, SD=2.6, n=30). Several age classes were represented in our samples, including juveniles and adults (Figure 13).

Coastrange sculpin were captured in the beach seine and in minnow traps. The beach seine yielded 0.45 fish/set while the minnow traps caught 0.02 fish/trap-hour. In general, coastrange sculpins were captured in relatively shallow, littoral waters using minnow traps and the beach seine. Most of the small sculpins (<40 mm) were captured in the beach seine.

***Ninespine Sticklebacks*—**Three hundred and fifteen ninespine sticklebacks were captured during the Nonvianuk phase of the species inventory (Figure 6). Ninespine sticklebacks ranged in TL from 26 to 68 mm (mean TL=50.2 mm, SD=6.5, n=167). Although more than one age class was present, a single age class with a mode at 52.5 mm was predominant (Figure 13).

Ninespines were common in beach seine catches as well as minnow traps. On average, 4.29 fish/set were captured in the beach seine and 0.12 fish/trap-hour using minnow traps. Ninespine sticklebacks were captured in littoral and deep benthic areas (2 m to 20 m). Some of the males captured from deep water minnow traps (10 m or 20 m) exhibited spawning colors. Ninespine sticklebacks were also captured in limnetic habitat during tow netting. The CPUE was less than two fish per net-hour (Table 5). These fish were exclusively males displaying spawning colors but all were lethargic and appeared to be senescent and near death.

***Round Whitefish*—**A total of 175 round whitefish were captured in Nonvianuk Lake (Figure 8). These fish ranged from 31 to 480 mm in FL (mean FL=150.9 mm, SD=76.8, n=174). The length frequency plot for this species indicated the presence of at least four age classes, including young-of-the-year (<40mm) and mature adults (Figure 13).

Round whitefish were captured in the beach seine and gill net. The CPUEs for both techniques were twice as high as those observed at Kukaklek Lake (Table 5). Similar to Kukaklek Lake, round whitefish were only caught near shore.

***Slimy Sculpin*—**Fourteen slimy sculpin were captured in Nonvianuk Lake (Figure 9). They ranged in TL from 31 to 74 mm (mean TL=45.3 mm, SD=13.7, n=9), but no clear age groups were evident in the length frequency plot (Figure 13). However, based on the range in sizes captured, it is likely that multiple age classes, including juveniles and adults, were represented in the sample.

Slimy sculpin were captured infrequently in beach seine sets and minnow traps (Table 5). They were also less abundant than coastrange sculpins at Nonvianuk Lake.

Threespine Stickleback—A total of 5,689 threespine stickleback were captured in Nonvianuk Lake (Figure 12). They were more abundant than all other undocumented species. These fish ranged in TL from 22 to 65 mm (mean TL=48.0 mm, SD=7.7, n=728). Two distinct length frequency modes around 32.5 mm and 52.5 mm indicated the presence of two major age classes (Figure 13). The smaller mode was likely young-of-the-year fish. Nonvianuk Lake differed from Kukaklek Lake in that stickleback over 60 mm were relatively uncommon (Figures 11 & 13).

Threespine sticklebacks were frequently captured in the beach seine and minnow traps. The CPUEs for these techniques were similar to those observed at Kukaklek Lake (Tables 4 & 5). Also similar to Kukaklek Lake, some of the largest beach seine catches were made up of a large proportion of juvenile sticklebacks.

A smaller number of threespine sticklebacks were found in the stomachs of predatory fish and in auger debris. Around 10 to 20 threespines were collected from the stomach contents of lake trout caught on hook-and-line in Nonvianuk Lake. Threespines appeared to be the only fish preyed upon by the small number of lake trout we examined. A single threespine stickleback was also collected through the ice during spring sampling. The fish was pumped to the surface by an ice auger that had penetrated the surface ice and was churning up sediments in the shallow water beneath.

Previously Documented Species

In addition to the undocumented fishes, a number of previously documented species were captured or observed during the inventory of the Alagnak Watershed. None of these were specifically targeted for the inventory and, in some cases, they were actively avoided (e.g., spawning salmon). Consequently our observations are extremely limited. These species included sockeye salmon (*Oncorhynchus nerka*), coho salmon (*O. kisutch*), chum salmon (*O. keta*), pink salmon (*O. gorbuscha*), chinook salmon (*O. tshawytscha*), rainbow trout (*O. mykiss*), lake trout (*Salvelinus namaycush*), and grayling (*Thymallus arcticus*) (Figures 14 through 20).

DISCUSSION

The nine species documented through the Alagnak inventory are consistent with species found in other southwest Alaska habitats. In the adjacent Naknek and Kvichak watersheds, all of the newly documented Alagnak species are present (Heard et al. 1969; McPhail and Lindsey 1970; Russell 1980; Mecklenburg et al. 2002). None of the species captured are unusual in the context of regional distribution patterns, consequently, no range extensions or unexpected species were identified within the Alagnak watershed.

While nine of 14 expected but undocumented species were found, five were not detected: humpback whitefish, least cisco, longnose sucker, pond smelt, and pygmy whitefish. These undetected species pose additional questions about sampling methods and the distributions of fishes within the watershed. An important question arising from these results is why were some species detected while others were not?

There are two explanations for the undocumented species: (1) incomplete documentation (i.e., not all species present in the Alagnak were detected during the inventory), or (2) the undocumented species are simply not present in the areas sampled. The former explanation could be the result of the sampling approach or variation in spatial and/or temporal distributions of the expected species within the Alagnak. The latter explanation could be the result of a wide range of biological or physical excluding mechanisms or barriers.

The primary indirect evidence for incomplete documentation is the current distributions of the undocumented but expected species and apparent lack of colonization barriers within the Alagnak. Humpback whitefish, least cisco, longnose sucker, pond smelt, and pygmy whitefish are all found in the adjacent Naknek (south) and Kvichak (north) watersheds and are distributed throughout other Bristol Bay drainages (Heard et al. 1969; McPhail and Lindsey 1970; Russell 1980; Mecklenburg et al. 2002). Further, the Alagnak watershed is a tributary to the lower Kvichak and is only separated from the mouth of the

Naknek by a distance of about 30km. Based on the presence of anadromous salmonids, which annually migrate to Nonvianuk and Kukaklek lakes, and the absence of waterfalls, or other visible impediments to migration, it does not appear that the Alagnak has physical barriers preventing colonization. In short, the Alagnak has nearby sources of colonizers and, apparently, no existing physical barriers to keep them out.

If the fishes are present, the question remains; why were they not captured or observed (i.e., documented)? One possibility is that not all habitats were sampled effectively. We spent the majority of the inventory targeting littoral habitat. This was done for two reasons (1) species richness is typically highest in littoral areas, and (2) our sampling effort was limited. We did sample benthic and limnetic habitats with gill nets, minnow traps, and tow nets but not to the extent of our littoral sampling. Consequently, some benthic and limnetic species may have been missed. This possibility seems strongest for pygmy whitefish, which are known to occupy deep benthic habitat and can be difficult to collect [e.g., pygmy whitefish inhabit Lake Superior but were not detected there until 1952, when benthic trawls were deployed at depths greater than 18.2 m (McPhail and Lindsey 1970)]. With additional forms of sampling gear, such as a benthic trawl, we may have had success capturing pygmy whitefish and some of the other species.

Another way incomplete documentation may have occurred is through a failure in either the deployment of sampling gear or the gear itself. In the case of the tow net, there was some evidence that one of these was occurring. Normally, tow netting in a sockeye salmon nursery lake will provide catches of juvenile sockeye, particularly in the month of August. Tow netting is routinely used to estimate the abundance of juvenile sockeye in nursery lakes (e.g., Rogers 1967). However, we were unable to catch a single juvenile sockeye during our tow netting at Nonvianuk and Kukaklek Lakes. The only fishes we did capture were lethargic, senescent sticklebacks. This suggests that (1) limnetic species, including sockeye, are uncommon in the lakes or (2) our tow netting technique may have only been effective for very slow moving fishes and not healthy limnetic inhabitants such as sockeye, pond smelt, or least cisco. We cannot rule out either possibility, but the total absence of any healthy limnetic fishes suggests a flaw with the net or its deployment. Aside from the tow net, there was also some indication that the smaller mesh size gill nets were ineffective. This was particularly clear with the uniform 2.5 cm mesh gill net with which no fish were captured. Similar reports of low capture efficiencies with small sized mesh have been reported in adjacent watersheds (Heard 1962). Capture efficiencies tend to decline when the twine (the material the net is constructed from) diameter is large relative to the mesh size of the net (Hovgård 1996). In the smaller mesh nets and panels (less than 2.5 cm) that we used, the diameter of the twine remained constant (0.28 mm monofilament) as the mesh size decreased, possibly reducing capture efficiency. Whether fish actively avoided the smaller mesh or failed to become entangled after contact is not clear, but it is apparent that the smaller mesh sizes did not catch fish. Some of the species that we did not capture (i.e., humpback whitefish, least cisco, pond smelt, and pygmy whitefish) may have been susceptible to smaller mesh sizes with smaller diameter twine.

Finally, the undocumented species may be present in the Alagnak watershed but not during the time period we sampled or inside the park units. Our sampling efforts were concentrated during the summer months and represented a limited snapshot of species presence. It is possible that the distributions of the undocumented species varied over time and did not overlap with our sampling efforts. Similarly, if any of the undocumented species were present but rare, it is possible that our sampling did not overlap their distribution. In either case, more extensive sampling would resolve the issue. It also worth noting that our inventory was conducted within the ALAG and KATM park units. Downstream of these other habitat types exist, which were not sampled but may contain additional species.

The species observed in the Alagnak freshwater fish inventory represent a partial picture of a southwest Alaska ecosystem. More work is needed to determine whether undocumented species are present, as well as the abundance, distributions and biological characteristics of documented species. With potential changes in climate and human use on the horizon, collecting baseline data, such as those contained in this inventory, is especially important to understanding and managing the factors that influence fish and their habitat.

PLANS FOR COMING YEAR

In 2003 we will continue analyses of data collected during the Alagnak inventory, as well as conduct a freshwater fish inventory in the Aniakchak National Monument and Preserve. The continuing Alagnak analyses will focus on the morphometric characteristics of round whitefish. We will be looking to see whether round whitefish are polymorphic across the habitats we sampled. The goal of this work is to determine whether or not intraspecific morphological variation is an additional source of biological species richness in the Alagnak watershed.

The Aniakchak inventory will be performed during the summer of 2003. We will be sampling in Surprise Lake, Aniakchak River, Meshik Lake, Meshik River, and opportunistically at additional rivers and streams. Similar to the Alagnak inventory, the focus of this work will be documenting *expected but undocumented* species. These include lampreys, blackfish, grayling, sculpins, suckers, sticklebacks, whitefish and lampreys.

Recommendations

There are a number of recommendations related to field equipment and sampling gear, that may benefit future inventories. First, an electric fence should be used to minimize interaction between bears and field camps. In KATM and ALAG bears are common enough that they are almost guaranteed to come in contact with the field camp. Fuel, fish, and other bear attractants are impossible to exclude from the inventory process and, therefore, must be isolated from bears. Having a charged electric fence around fuel presents a safety hazard, so fence placement and fuel placement should be carefully considered to avoid contact between the two. Second, a bathymetric chart would be a good addition to any lake sampling effort. Currently, none are available for Nonvianuk and Kukaklek lakes. Choosing sampling sites and navigating without a chart was difficult and somewhat time consuming given the large size of the lakes. Third, tow nets should probably not be used with rafts. In Nonvianuk Lake we attempted to tow net on several occasions with outboard powered rafts but were unable to do so effectively because the rafts tended to drift out of alignment rapidly even under ideal conditions (i.e., no wind). The light weight of the rafts and lack of a rigid keel or chines probably contributed to the poor performance of the tow netting operation. When aluminum jet boats were available, we had better success deploying the net. Finally, down time for weather should be figured into the sampling plan. Heavy winds and poor visibility often disrupted our sampling or transportation to field sites.

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Hamon, Susan Kedzie-Webb, William Leacock, Alan Bennett, and Tom O'Hara.

This report is dedicated to the memory of Tom O'Hara.

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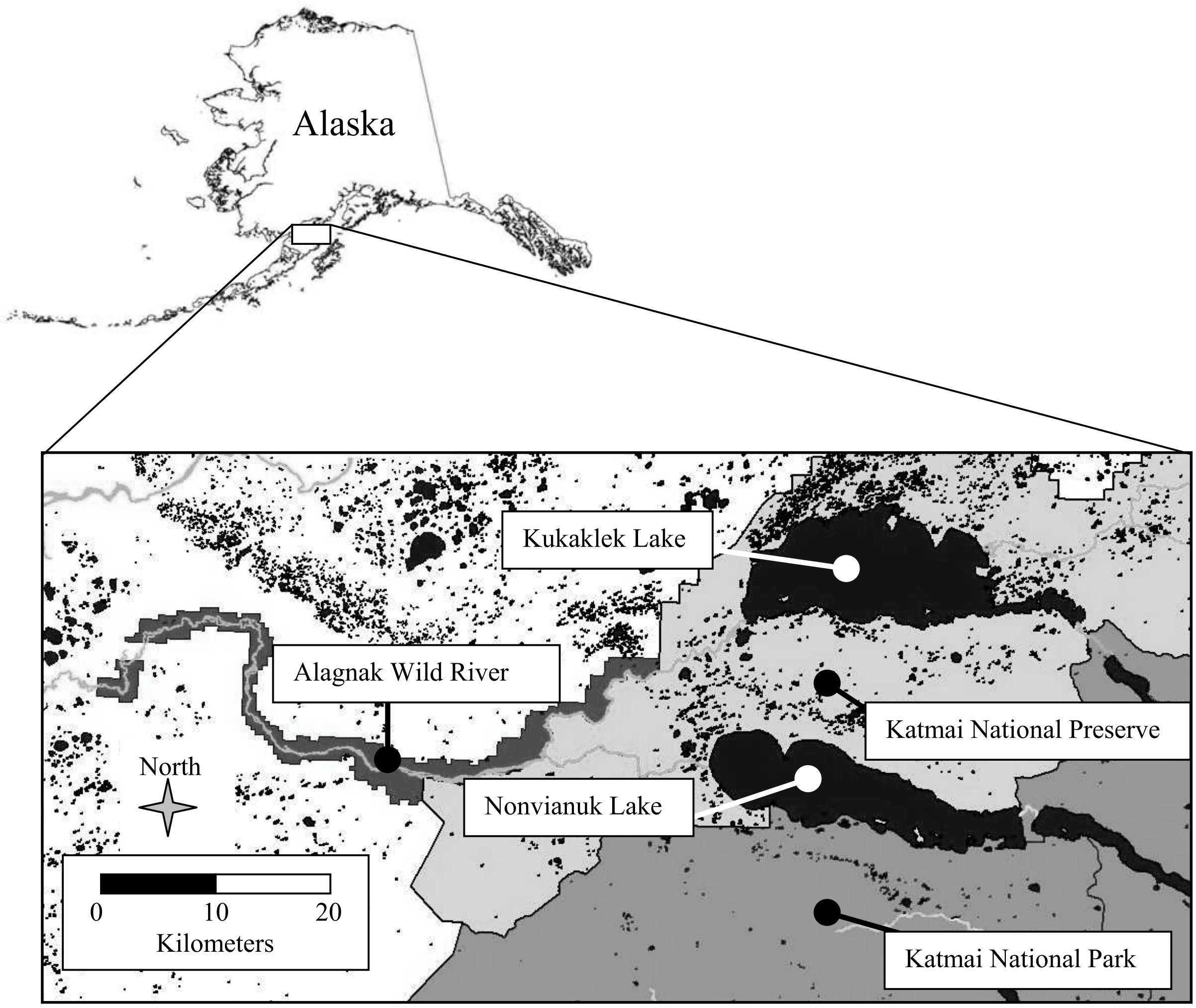

Figure 1. Location of the 2002 freshwater fish inventory within the Alagnak Watershed. Park units are labeled and boundaries are contained within shaded regions of map.

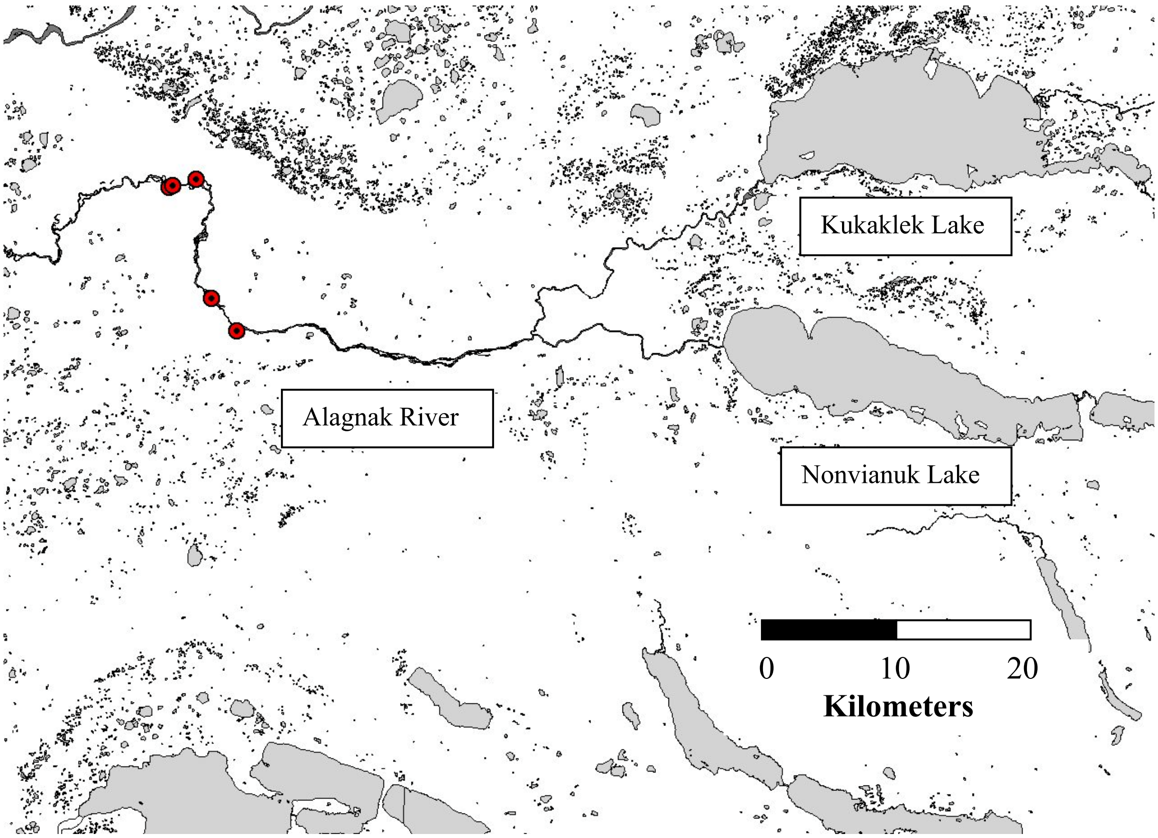

Figure 2. Documented distribution of Alaska blackfish (*Dallia pectoralis*) resulting from the 2002 freshwater fish inventory of the Alagnak Watershed. Individual capture or observation locations are denoted by the round bull's eye symbol.

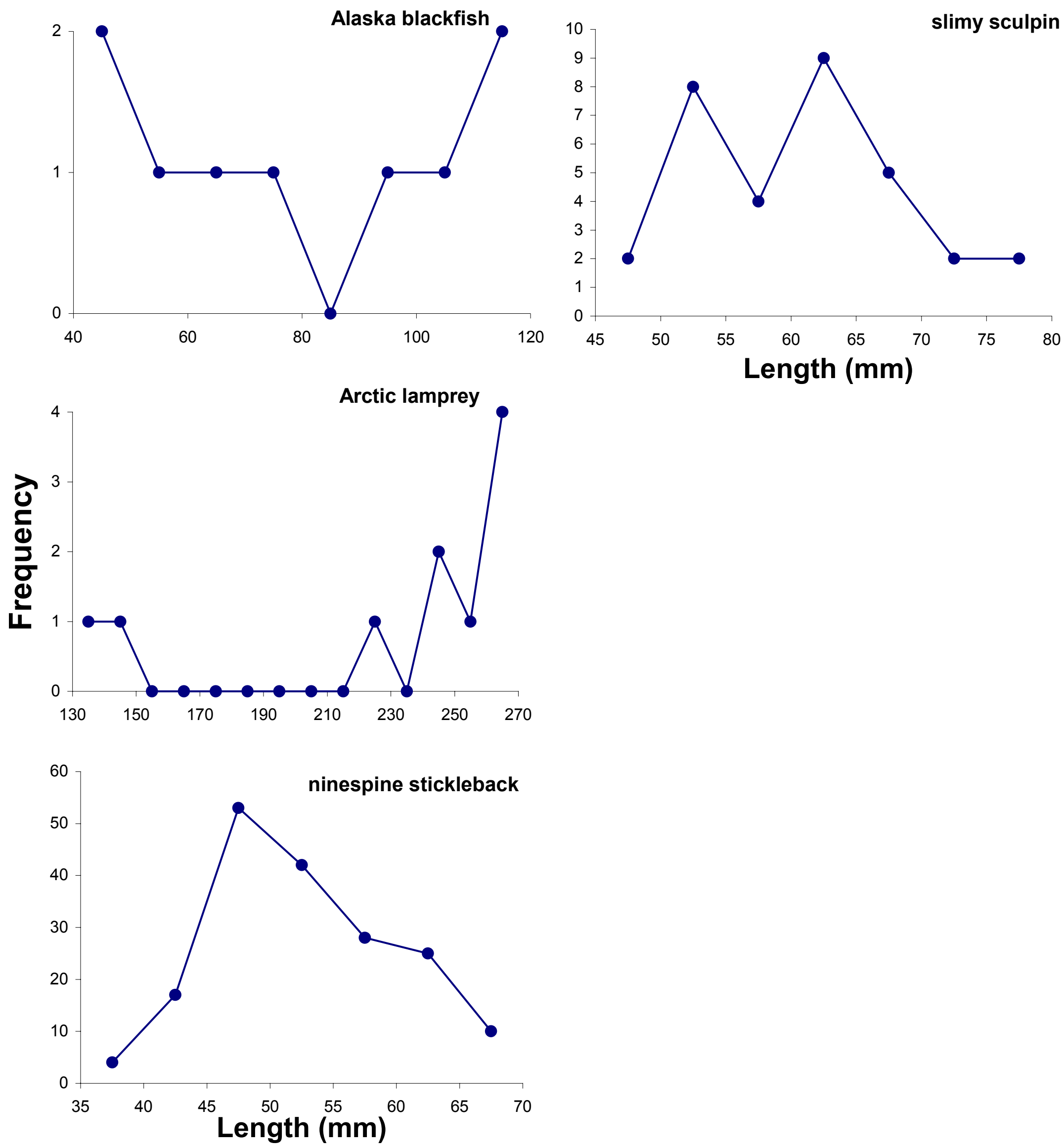

Figure 3. Length frequencies for species captured in the Alagnak River during the 2002 freshwater fish inventory. All data points reflect the number of observations within length increments of 5 mm or 10 mm. Species with fewer than five observations are omitted. All species measured for total length.

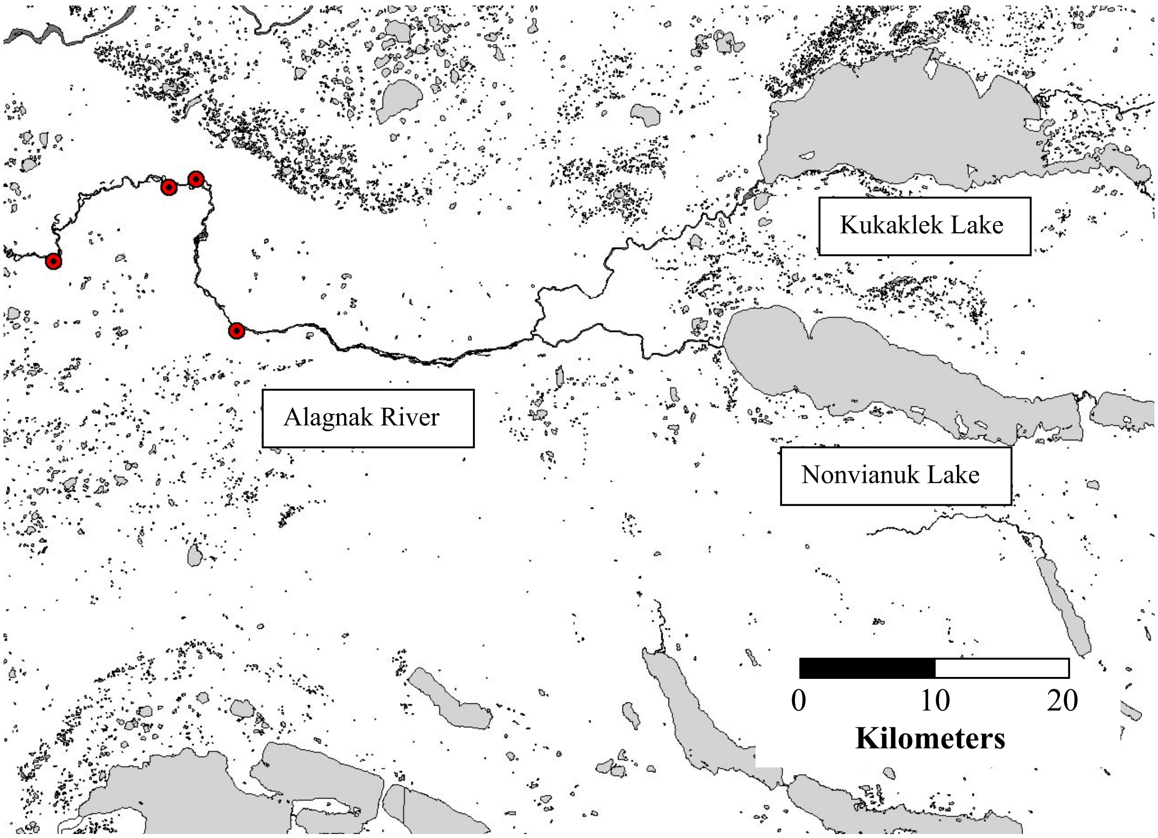

Figure 4. Documented distribution of Arctic lamprey (*Lampetra japonica*) resulting from the 2002 freshwater fish inventory of the Alagnak Watershed. Individual capture or observation locations are denoted by the round bull's eye symbol.

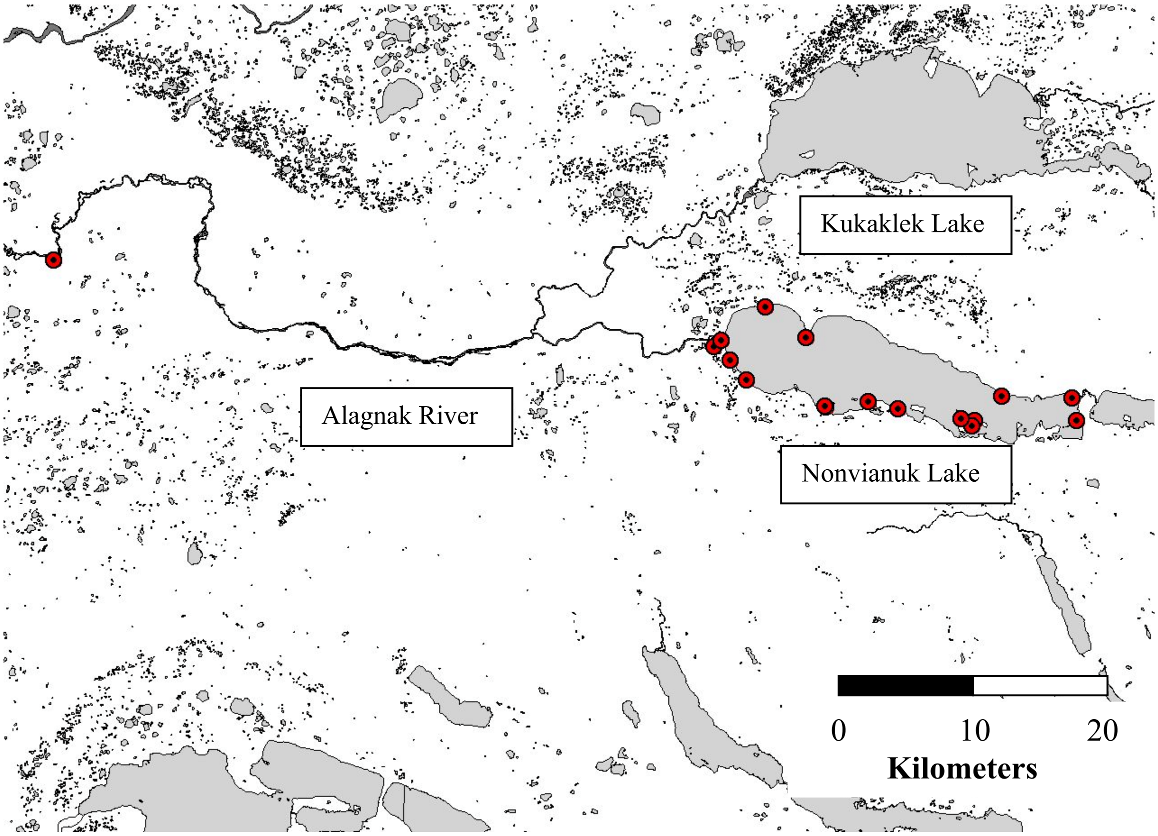

Figure 5. Documented distribution of coastrange sculpin (*Cottus aleuticus*) resulting from 2002 freshwater fish inventory of the Alagnak Watershed. Individual capture or observation locations are denoted by the round bull's eye symbol.

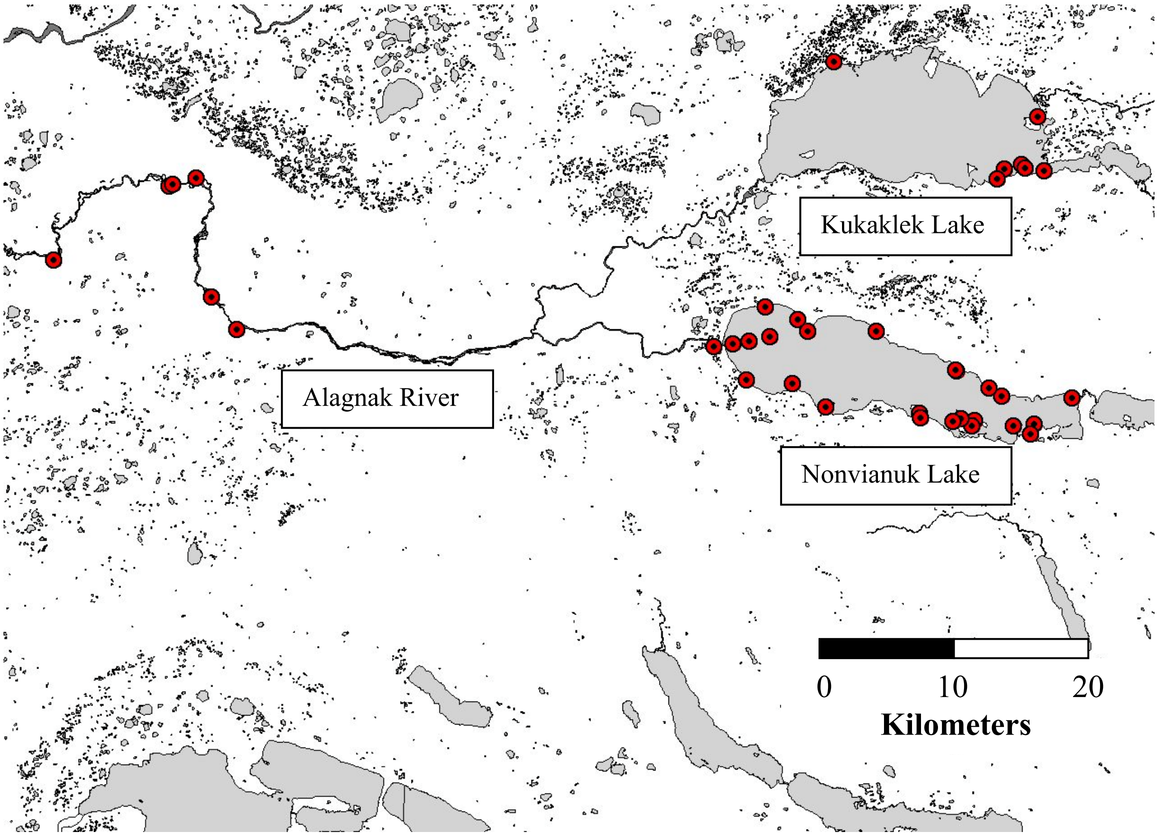

Figure 6. Documented distribution of ninespine stickleback (*Pungitius pungitius*) resulting from the 2002 freshwater fish inventory of the Alagnak Watershed. Individual capture or observation locations are denoted by the round bull's eye symbol.

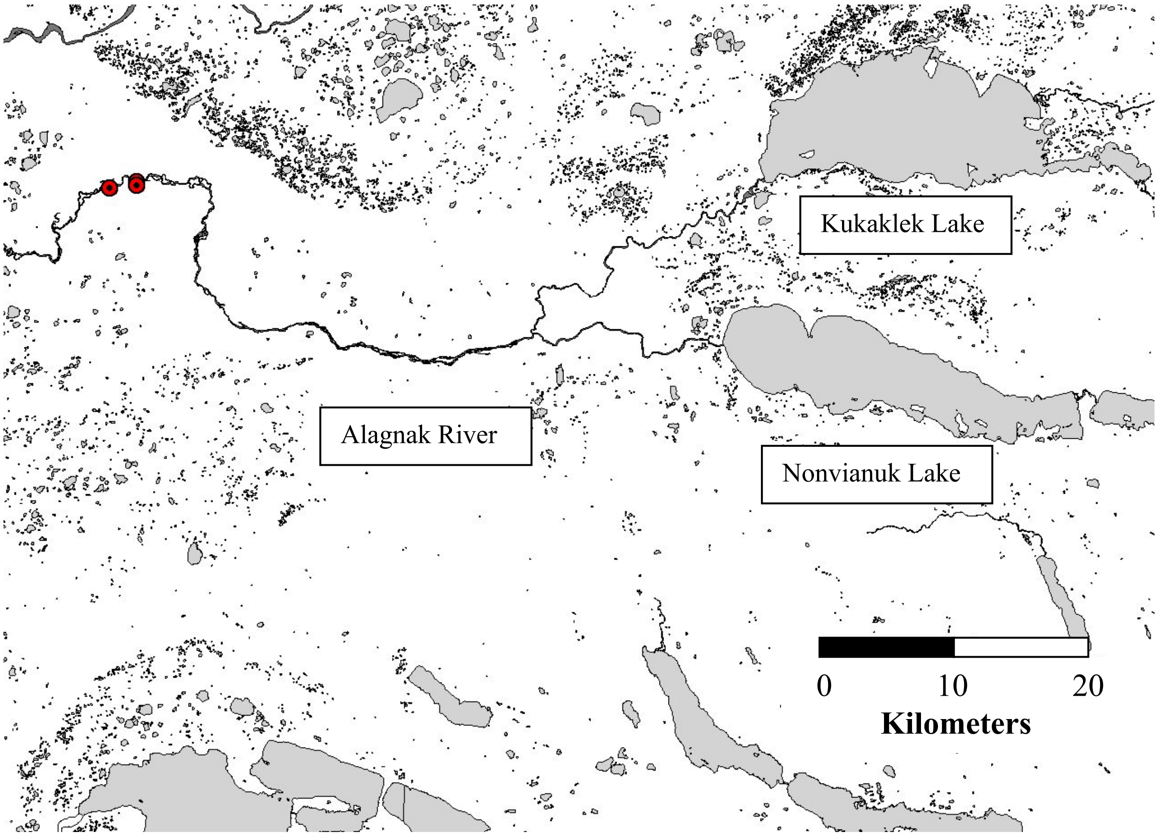

Figure 7. Documented distribution of northern pike (*Esox lucius*) resulting from the 2002 freshwater fish inventory of the Alagnak Watershed. Individual capture or observation locations are denoted by the round bull's eye symbol.

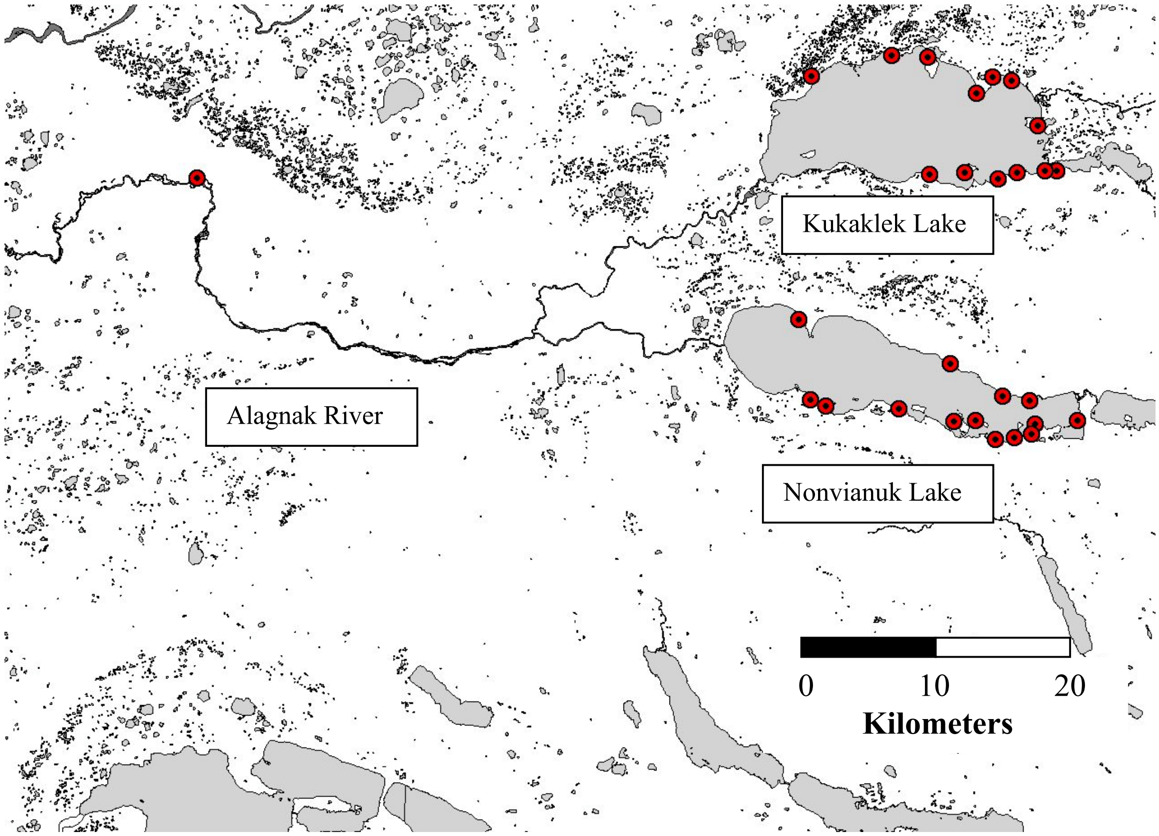

Figure 8. Documented distribution of round whitefish (*Prosopium cylindraceum*) resulting from the 2002 freshwater fish inventory of the Alagnak Watershed. Individual capture or observation locations are denoted by the round bull's eye symbol.

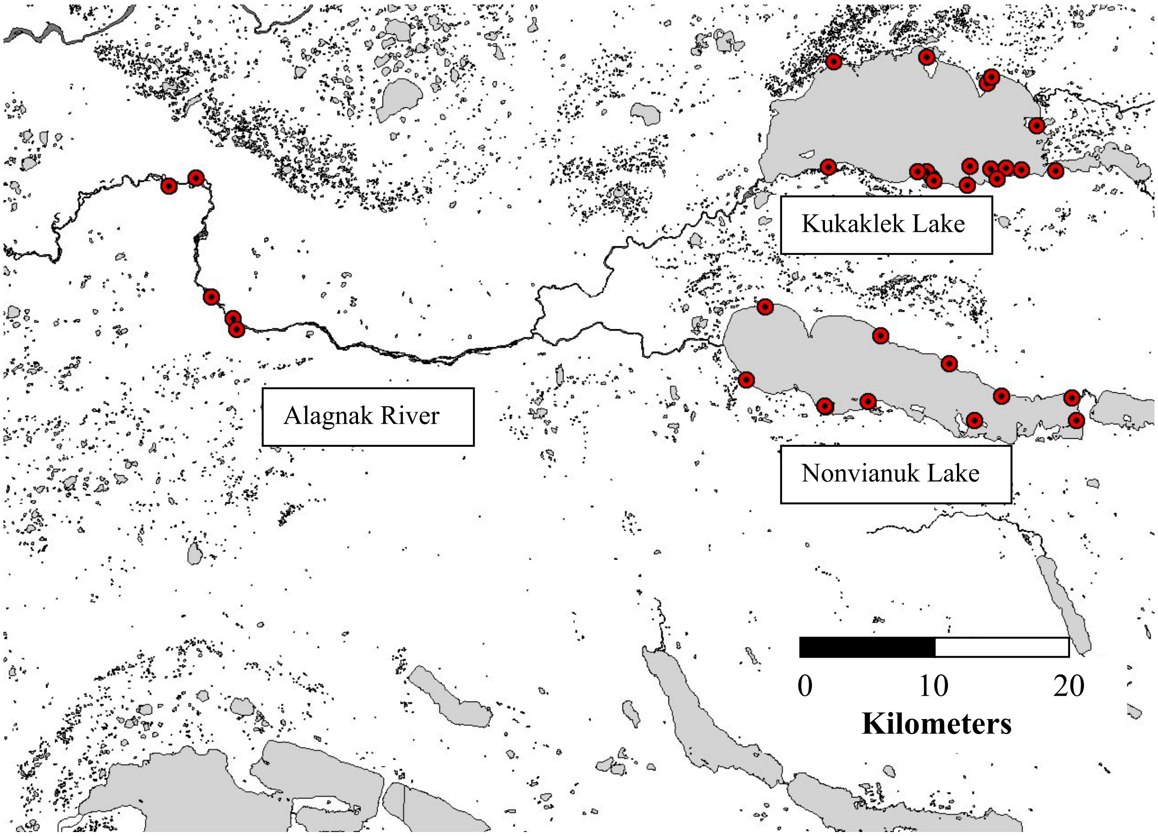

Figure 9. Documented distribution of slimy sculpin (*Cottus cognatus*) resulting from the 2002 freshwater fish inventory of the Alagnak Watershed. Individual capture or observation locations are denoted by the round bull's eye symbol.

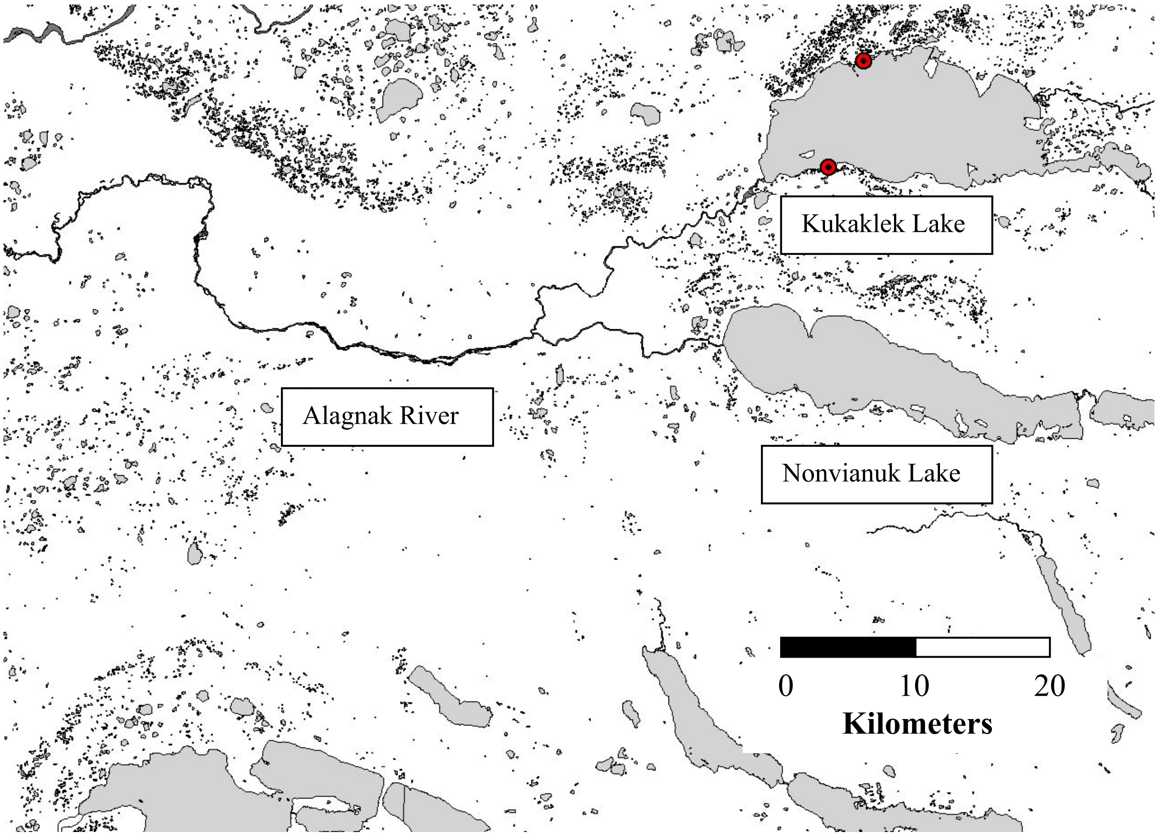

Figure 10. Documented distribution of burbot (*Lota lota*) resulting from the 2002 freshwater fish inventory of the Alagnak Watershed. Individual capture or observation locations are denoted by the round bull's eye symbol.

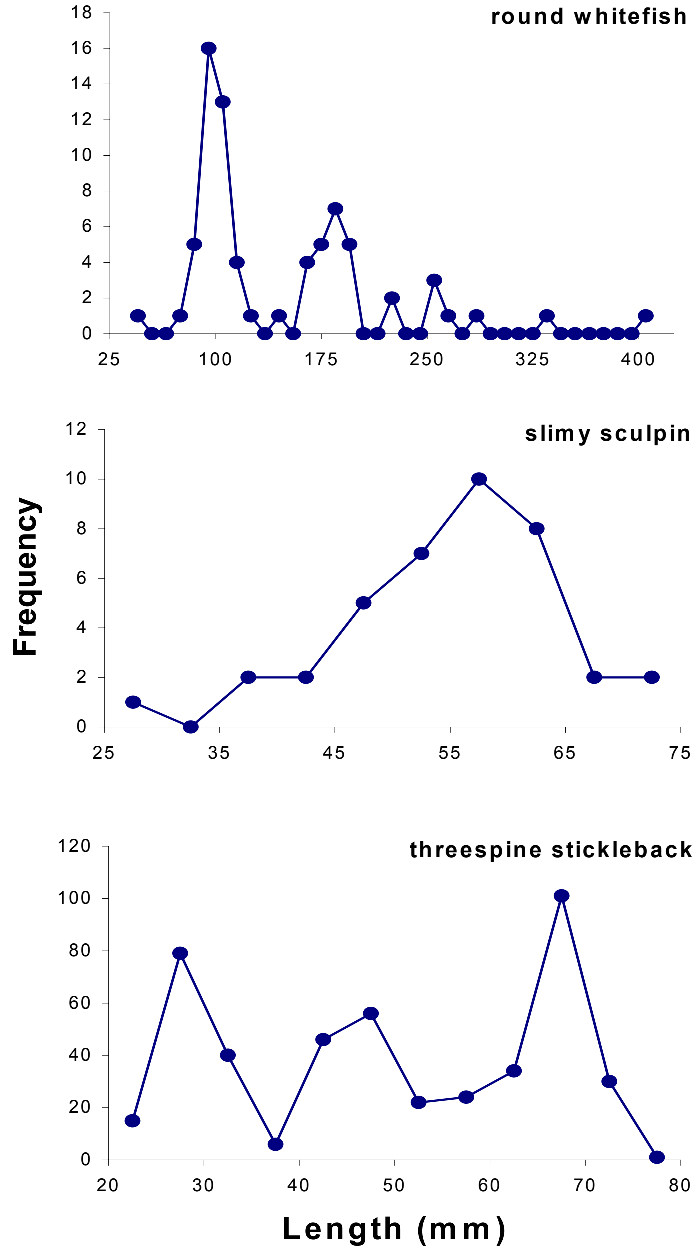

Figure 11. Length frequencies for species captured in Kukaklek Lake. Data points reflect the number of observations within length increments of 5 mm or 10 mm. Species with fewer than five observations are omitted. Fork length was measured for round whitefish, total length for other species.

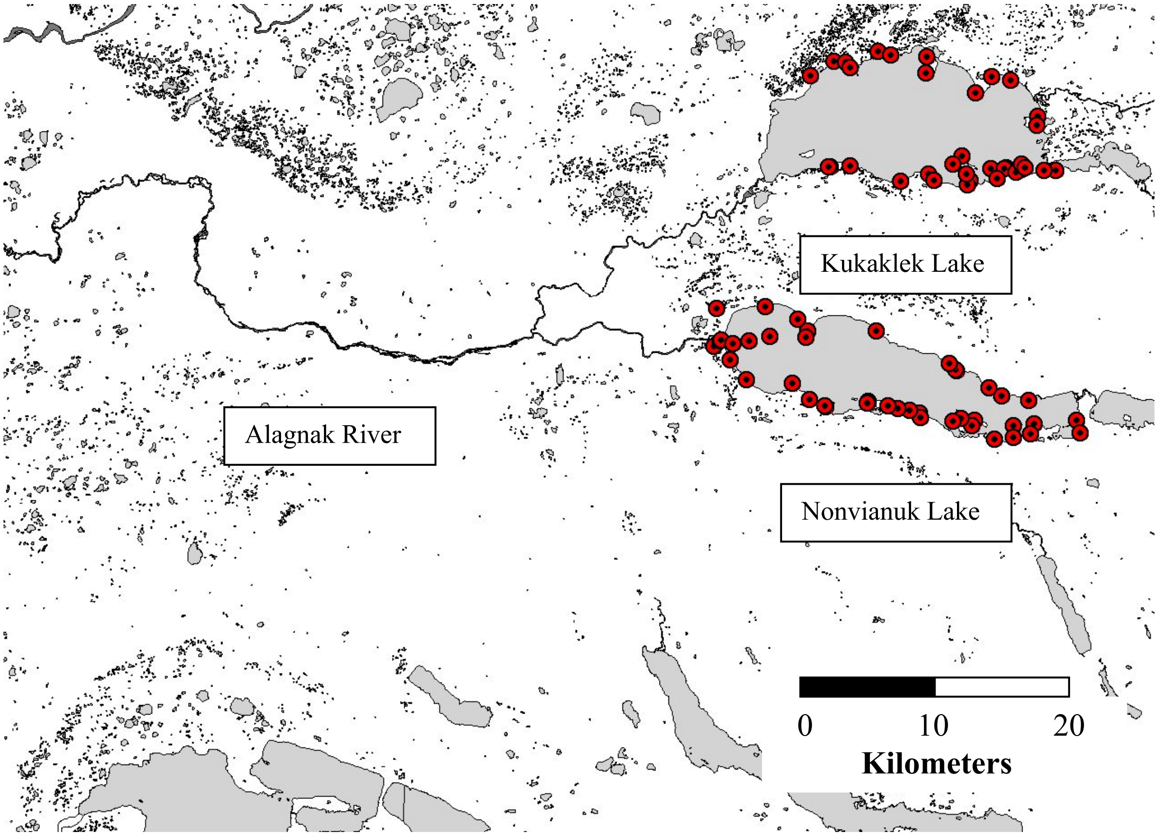

Figure 12. Documented distribution of threespine stickleback in the Alagnak Watershed. Individual capture or observation locations are denoted by the round bull’s eye symbol.

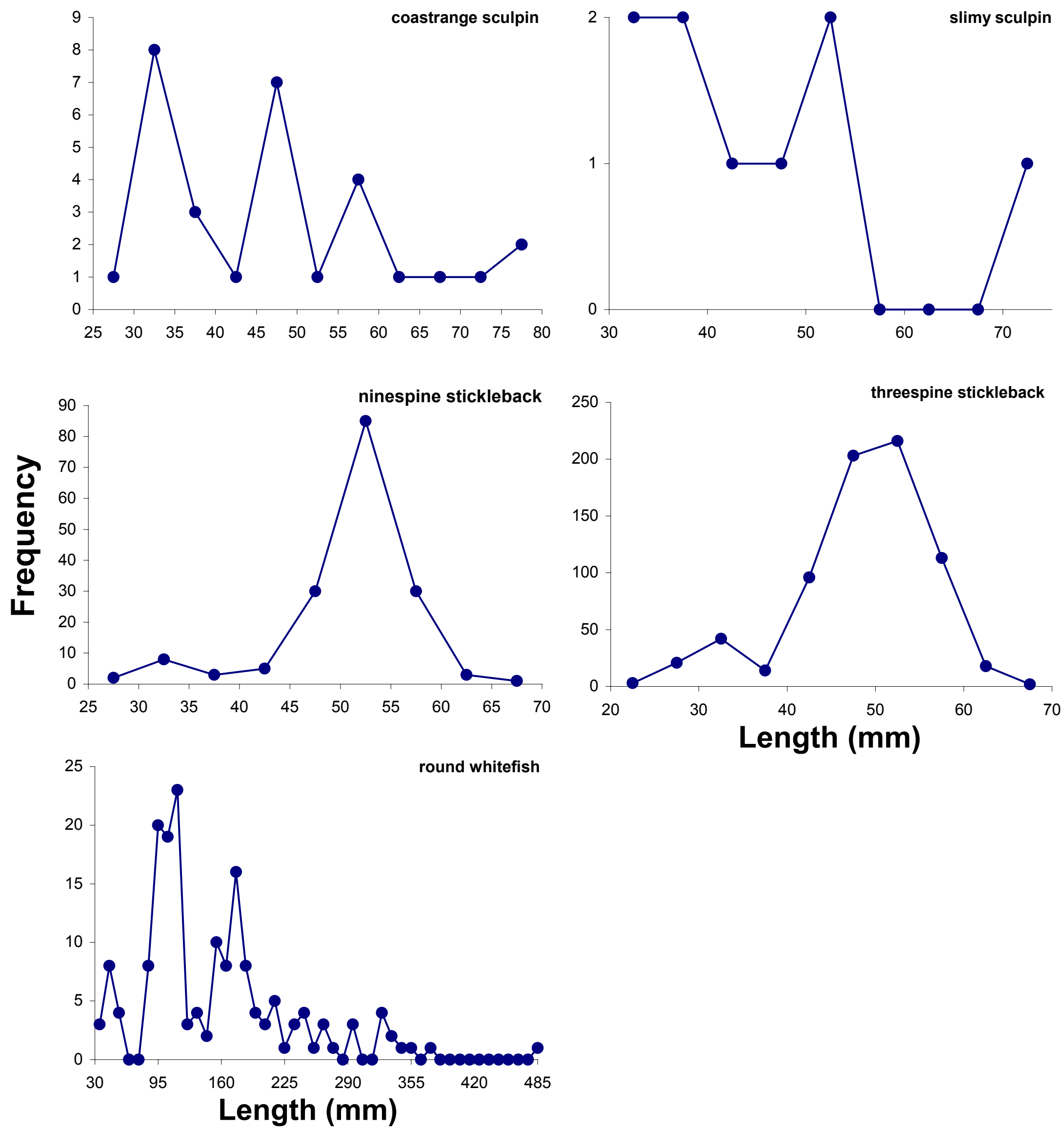

Figure 13. Length frequencies for species captured in Nonvianuk Lake. Data points reflect the number of observations within length increments of 5 mm or 10 mm. Species with fewer than five observations are omitted. Fork length was measured for round whitefish, total length for other species.

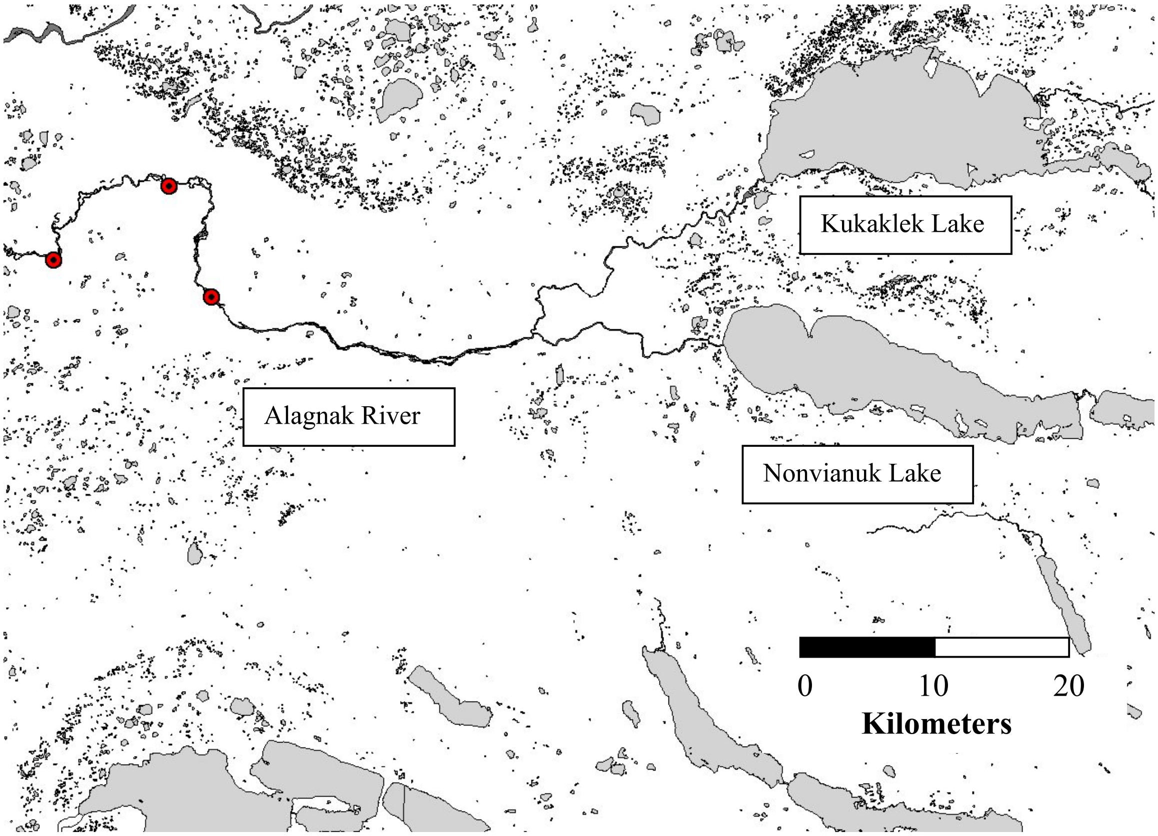

Figure 14. Documented distribution of chinook salmon (*Oncorhynchus tshawytscha*) resulting from the 2002 freshwater fish inventory of the Alagnak Watershed. Individual capture or observation locations are denoted by the round bull's eye symbol.

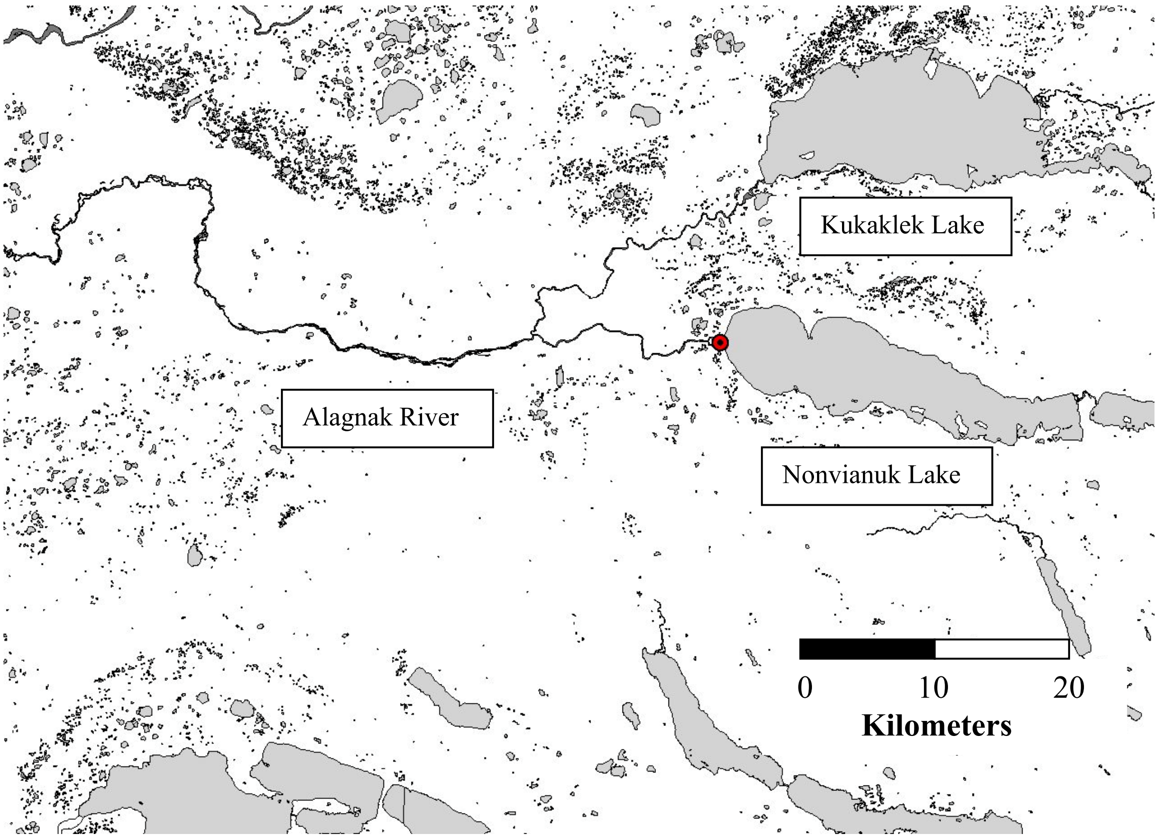

Figure 15. Documented distribution of chum salmon (*Oncorhynchus keta*) resulting from the 2002 freshwater fish inventory of the Alagnak Watershed. Individual capture or observation locations are denoted by the round bull's eye symbol.

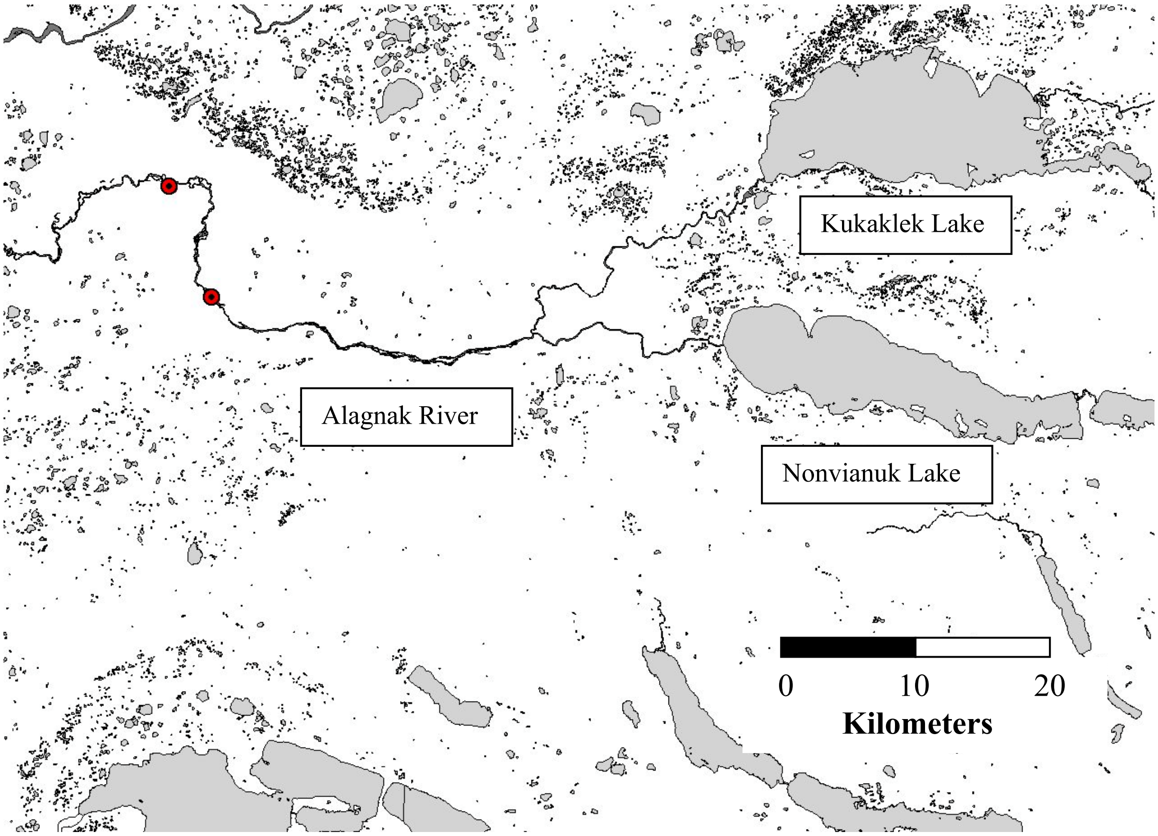

Figure 16. Documented distribution of coho salmon (*Oncorhynchus kisutch*) resulting from the 2002 freshwater fish inventory of the Alagnak Watershed. Individual capture or observation locations are denoted by the round bull's eye symbol.

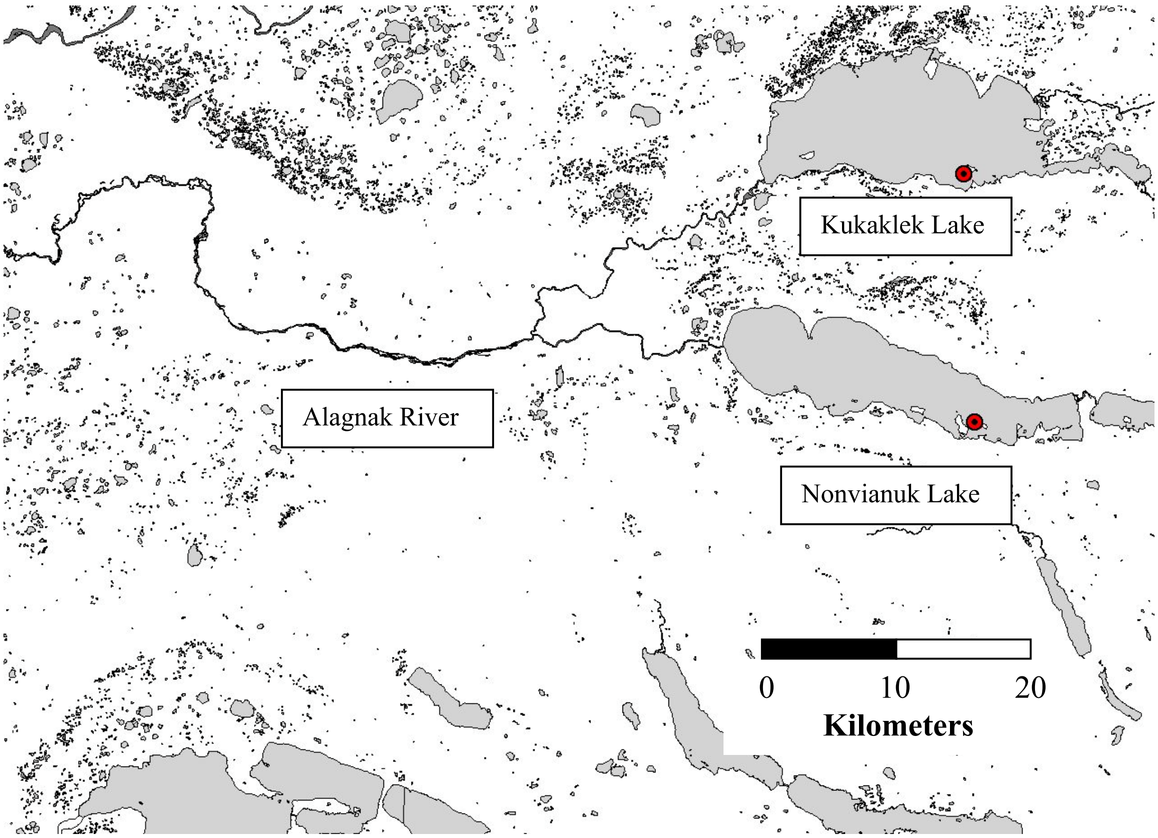

Figure 17. Documented distribution of lake trout (*Salvelinus namaycush*) resulting from the 2002 freshwater fish inventory of the Alagnak Watershed. Individual capture or observation locations are denoted by the round bull's eye symbol.

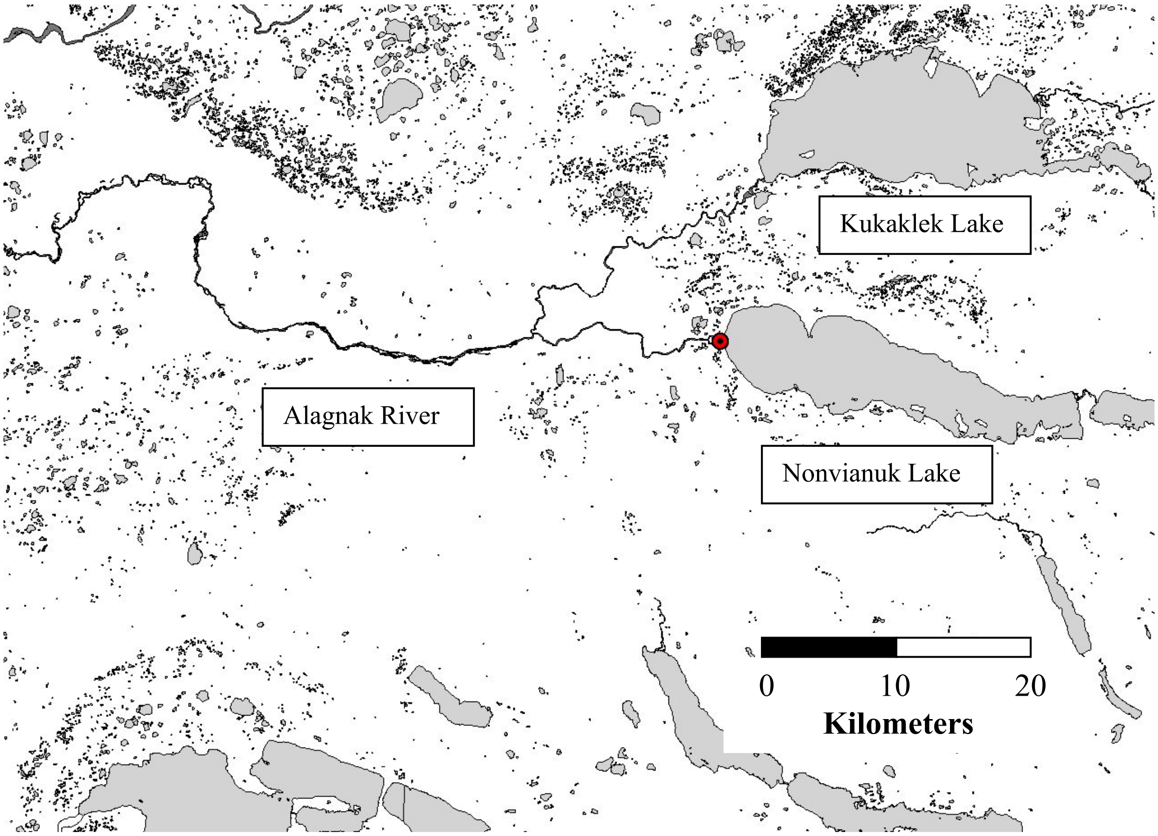

Figure 18. Documented distribution of pink salmon (*Oncorhynchus gorbuscha*) resulting from the 2002 freshwater fish inventory of the Alagnak Watershed. Individual capture or observation locations are denoted by the round bull's eye symbol.

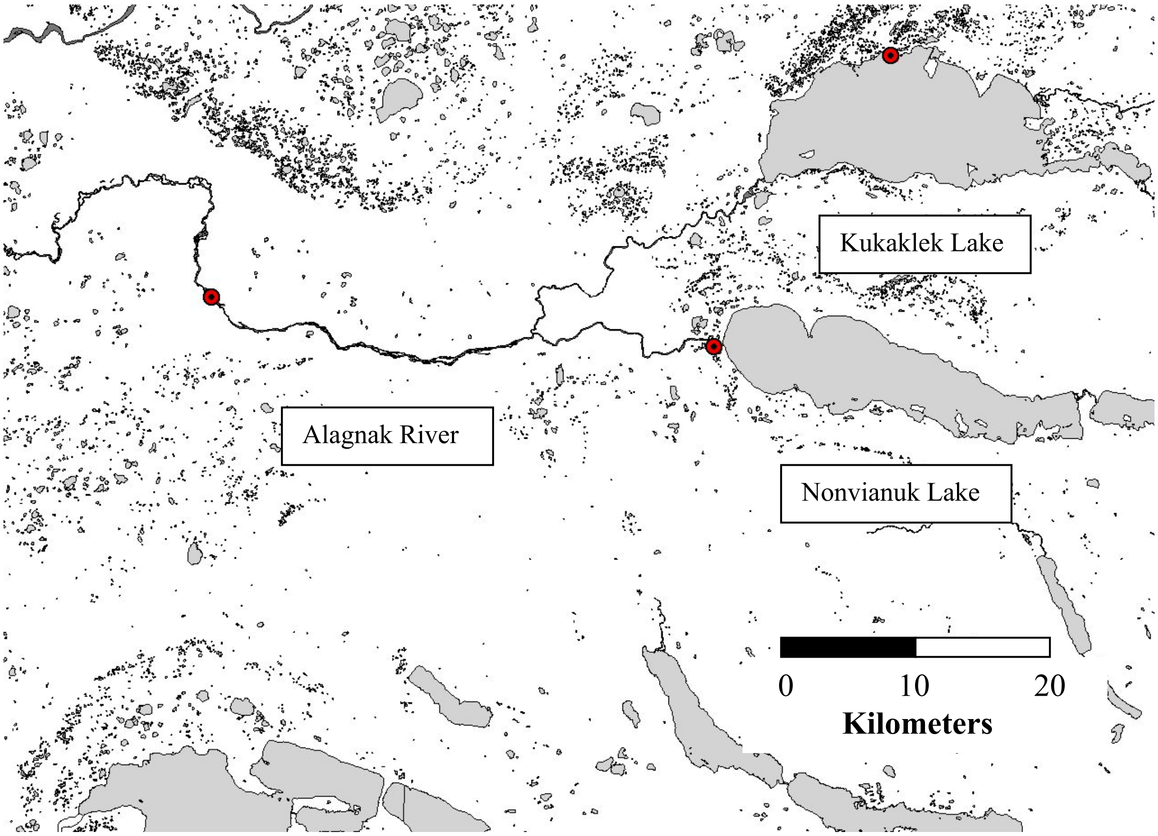

Figure 19. Documented distribution of rainbow trout (*Oncorhynchus mykiss*) resulting from the 2002 freshwater fish inventory of the Alagnak Watershed. Individual capture or observation locations are denoted by the round bull's eye symbol.

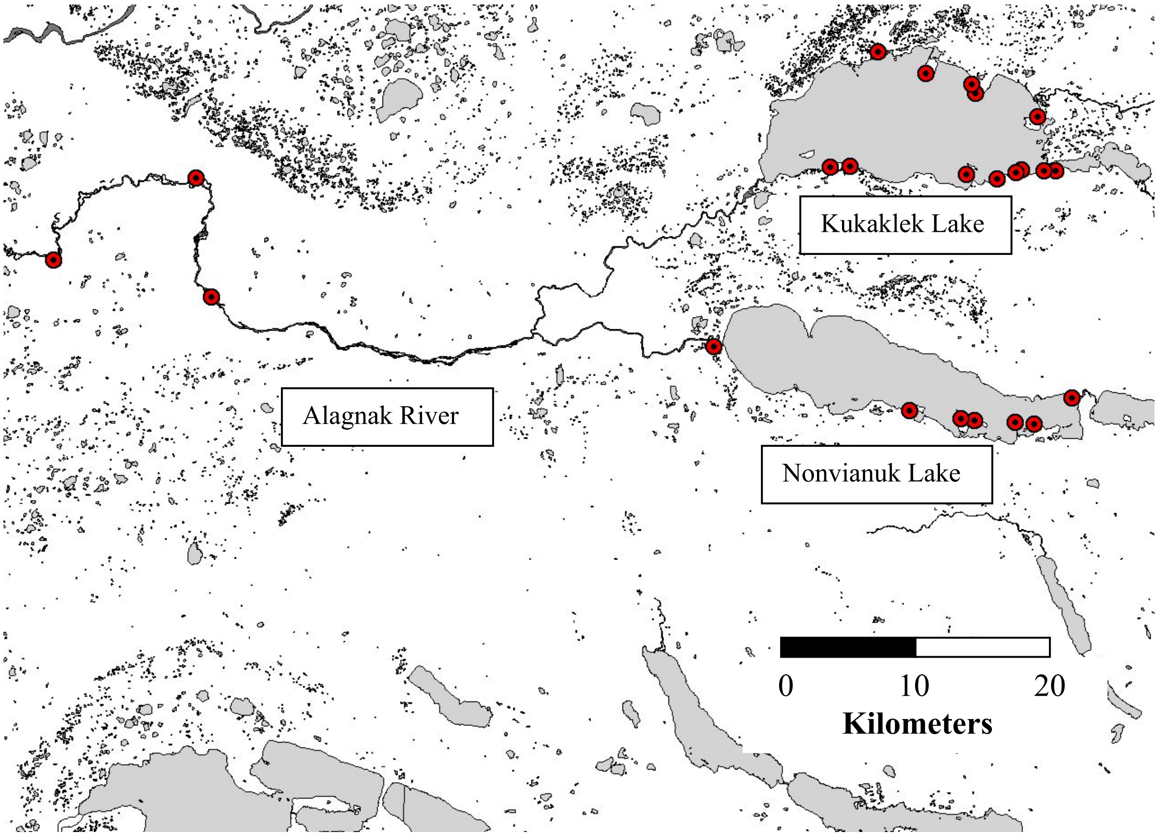

Figure 20. Documented distribution of juvenile sockeye salmon (*Oncorhynchus nerka*) resulting from the 2002 freshwater fish inventory of the Alagnak Watershed. Individual capture or observation locations are denoted by the round bull's eye symbol..

Species	Location		
	Alagnak River	Kukaklek Lake	Nonvianuk Lake
Alaska Blackfish *(Dallia pectoralis)*	9	0	0
Arctic Lamprey *(Lampetra japonica)*	10	0	0
Burbot *(Lota lota)*	0	3	0
Coastrange Sculpin *(Cottus aleuticus)*	1	0	46
Ninespine Stickleback *(Pungitius pungitius)*	548	13	315
Northern Pike *(Esox lucius)*	4	0	0
Round Whitefish *(Prosopium cylindraceum)*	5	80	175
Slimy Sculpin *(Cottus cognatus)*	38	51	14
Threespine Stickleback *(Gasterosteus aculeatus)*	0	5153	5689

Table 1. Numbers of expected but undocumented fish species observed or captured in the Alagnak River, Kukaklek Lake, and Nonvianuk Lake during the 2002 freshwater fish inventory.

Gear (effort unit)	Alagnak River	Kukaklek Lake	Nonvianuk Lake
Beach Seine (sets)	0.00	29.00	31.00
Minnow Seine (sets)	35.00	0.00	0.00
Gill Net (hours)	4.00	45.25	15.66
Fyke Net (hours)	25.25	0.00	0.00
Minnow Trap (trap hours)	514.50	973.00	1390.30
Hook-and-Line (hook hours)	10.00	126.00	71.00
Tow Net (hours)	0.00	0.00	5.42
Snorkeling (hours)	4.00	0.00	2.00

Table 2. Sampling effort among locations using different gear types during the 2002 freshwater fish inventory. Units of measurement vary among gear types. A set is a single deployment and retrieval of a net. Trap-hour and hook-hour effort units reflect the number of traps or hooks deployed multiplied by the number of hours the gear was fished (e.g., three traps fished for three hours = nine trap-hours of effort)

Species	Minnow Seine (fish/set)	Fyke Net (fish/hour)	Minnow Trap (fish/trap-hour)	Snorkel-Hand Net (fish/hour)
Alaska Blackfish *(Dallia pectoralis)*	0.27	0.00	0.01	0.00
Arctic Lamprey *(Lampetra japonica)*	0.00	0.36	0.00	0.00
Burbot *(Lota lota)*	0.00	0.00	0.00	0.00
Coastrange Sculpin *(Cottus aleuticus)*	0.00	0.04	0.00	0.00
Ninespine Stickleback *(Pungitius pungitius)*	3.09	0.24	0.99	0.00
Northern Pike *(Esox lucius)*	0.12	0.00	0.00	0.00
Round Whitefish *(Prosopium cylindraceum)*	0.00	0.00	0.00	0.00
Slimy Sculpin *(Cottus cognatus)*	0.46	0.52	0.02	10.40
Threespine Stickleback *(Gasterosteus aculeatus)*	0.00	0.00	0.00	0.00

Table 3. Catch per unit of effort (CPUE) for documented species at the Alagnak River using different gear types during the 2002 freshwater fish inventory. Units of measurement vary among gear types. Trap-hour and hook-hour effort units reflect the number of traps or hooks deployed multiplied by the number of hours the gear was fished (e.g., three traps fished for three hours = nine trap-hours of effort). CPUEs are not reported for gear types that did not capture fish.

Species	Beach Seine (fish/set)	Gill Net (fish/hour)	Minnow Trap (fish/trap-hour)	Hook-and-Line (fish/hook-hour)
Alaska Blackfish *(Dallia pectoralis)*	0.00	0.00	0.00	0.00
Arctic Lamprey *(Lampetra japonica)*	0.00	0.00	0.00	0.00
Burbot *(Lota lota)*	0.00	0.00	0.00	0.02
Coastrange Sculpin *(Cottus aleuticus)*	0.00	0.00	0.00	0.00
Ninespine Stickleback *(Pungitius pungitius)*	0.24	0.00	0.01	0.00
Northern Pike *(Esox lucius)*	0.00	0.00	0.00	0.00
Round Whitefish *(Prosopium cylindraceum)*	2.55	0.13	0.00	0.00
Slimy Sculpin *(Cottus cognatus)*	1.35	0.00	0.01	0.00
Threespine Stickleback *(Gasterosteus aculeatus)*	172.66	0.00	0.15	0.00

Table 4. Catch per unit of effort (CPUE) for documented species at Kukaklek Lake using different gear types during the 2002 freshwater fish inventory. Units of measurement vary among gear types. Trap-hour and hook-hour effort units reflect the number of traps or hooks deployed multiplied by the number of hours the gear was fished (e.g., three traps fished for three hours = nine trap-hours of effort). CPUEs are not reported for gear types that did not capture fish.

Species	Beach Seine (fish/set)	Gill Net (fish/hour)	Minnow Trap (fish/trap-hour)	Tow Net (fish/hour)
Alaska Blackfish *(Dallia pectoralis)*	0.00	0.00	0.00	0.00
Arctic Lamprey *(Lampetra japonica)*	0.00	0.00	0.00	0.00
Burbot *(Lota lota)*	0.00	0.00	0.00	0.00
Coastrange Sculpin *(Cottus aleuticus)*	0.45	0.00	0.02	0.00
Ninespine Stickleback *(Pungitius pungitius)*	4.29	0.00	0.12	1.85
Northern Pike *(Esox lucius)*	0.00	0.00	0.00	0.00
Round Whitefish *(Prosopium cylindraceum)*	5.51	0.26	0.00	0.00
Slimy Sculpin *(Cottus cognatus)*	0.22	0.00	0.00*	0.00
Threespine Stickleback *(Gasterosteus aculeatus)*	178.55	0.00	0.10	2.95

Table 5. Catch per unit of effort (CPUE) for documented species at Nonvianuk Lake using different gear types during the 2002 freshwater fish inventory. Units of measurement vary among gear types. Trap-hour and hook-hour effort units reflect the number of traps or hooks deployed multiplied by the number of hours the gear was fished (e.g., three traps fished for three hours = nine trap-hours of effort). CPUEs are not reported for gear types that did not capture fish. (*indicates fewer than 0.01 fish/trap hour were captured)